POWER

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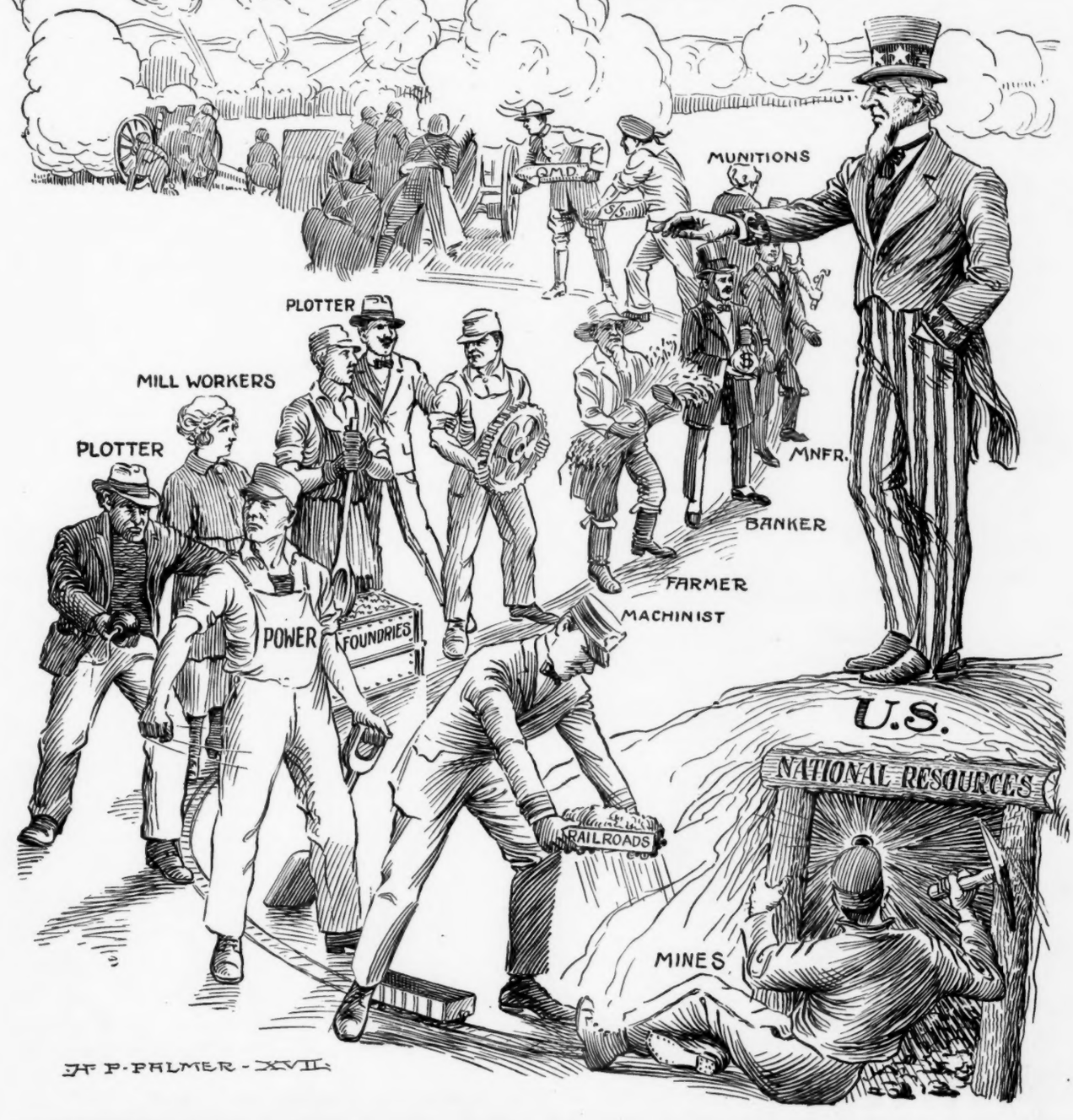
THE VICTORY LINE

„OUR PRESENT AND IMMEDIATE TASK IS TO WIN THE WAR, AND NOTHING SHALL TURN US ASIDE FROM IT UNTIL IT IS ACCOMPLISHED."

PRESIDENT WILSON TO CONGRESS, DEC. 4, 1917.



The Year's Progress in The Power Field

DURING the last year war has been the one great factor influencing the power field. In certain branches it has brought forth intensive development (the "Liberty" motor, for example), but for the most part progress has been delayed. In the face of readjustment of labor due to the call of the army, shortage of coal and raw materials and inadequate transportation facilities, maximum production has absorbed largely the energy of the mechanical industry. There have been enormous demands for boilers, prime movers and auxiliary equipment for the numerous boats now building. To keep pace with the great output from the shops, power-plant capacity has been increased with a decided tendency toward the use of larger units. Comparatively small plants that not long ago considered machines of 5000-kw. capacity large, are now installing 10,000-kw. turbo-generators with the idea of larger machines on the next order. This has led to the use of larger boilers, stokers and condensers. Over a period of years there has been steady progress in this direction and a trend toward higher pressures accompanied by superheat of increasing degree. Back of this has been the demand for higher efficiencies, due to the rising price of fuel. For the same reason the economizer is no longer a doubtful investment, and impetus has been given toward improving the economy of all auxiliaries.

The Trend Toward Higher Pressures

With proper selection of available equipment and close attention to air leakage it is now possible to maintain a vacuum 97 per cent. perfect, leaving little to gain. At the upper end of the thermal cycle the opportunity for improvement is greater. With present materials and designs a maximum initial temperature of 700 deg. is considered the practical limit. Made up in the proper proportions by pressure and superheat, there is a possible 10 to 12 per cent. gain in economy over present results. Increase of friction with the density of the steam, the greater expansion and contraction and other practical difficulties detract from the previous theoretical estimate, but even a portion of the gain mentioned is worth striving for. Turbine builders see no insurmountable difficulties in perfecting their machines for the higher pressures. However, radical changes in boiler and valve design will be necessary. The pressure limit for the standard boiler has been placed at 350 lb., whereas 500 to 600 lb. is anticipated. Experimental work to develop boilers for these pressures is now in process. At the present time pressures up to 250 lb. are common, and during the last year a number of installations were made or planned in which the pressures will be higher.

Notable Steam Plants

At Joliet, the Public Service Company of Northern Illinois has cross-drum boilers designed for 350 lb. pressure and 225 deg. of superheat. This is the highest pressure used in a central-station plant in this country, and it is generally conceded that it is about the limit for boilers of the present standard design. In the same plant an innovation is the use of a horizontal all-steel individual economizer placed above and integral with the boiler, the whole being inclosed by a steel casing. Although careful tests have not been made as yet, the boilers have been in operation long enough to indicate that they will develop exceptionally high capacities and that the efficiency may exceed 80 per cent.

To withstand the high pressure the plates of the boiler drum are $1\frac{5}{16}$ in. thick and the longitudinal seam is a quadruple-riveted butt joint with double cover straps. The boiler tubes are of lower gage than in boilers designed for 250 lb. pressure, and the metal in the economizer tubes is one-quarter inch thick. Valves that had been previously designed for the pressure were available, the piping is extra heavy and the joints are of the bolted type having a welded seal commonly employed by Sargent & Lundy for high pressures. With smooth metal-to-metal joints, the difficulties that gaskets would cause are eliminated. At normal load a steam velocity of 7200 ft. per min. in the turbine leads is employed. This permits piping of comparatively small diameters, so that the initial cost is very little more than for pressures of 250 pounds.

Extensions to many plants have been made, and a number of new stations have been placed in operation during the year. Perhaps the most notable is the new steam station of the Buffalo General Electric Co. designed for 275 lb. pressure and 275 deg. of superheat, giving a total steam temperature of 689 deg. The station was planned for a capacity of 200,000 kw., but the initial installation was 60,000 kw. in three units. The boilers are of the cross-drum type having 11,400 sq.ft. of steam-making surface each. They are fired at both ends by two 15-retort underfeed stokers. This duplex stoker setting, measuring at the grate level nearly 24 ft. wide by $17\frac{1}{2}$ ft. deep, is the largest ever built, and the ratio of grate area to heating surface, 1 to 27.3, is probably the most liberal employed in power-plant practice. At normal rating a trifle less than two tons of coal per hour is fed to each boiler. The stokers are capable of supplying 15 tons per boiler per hour, and when feeding $10\frac{1}{2}$ tons per hour per boiler, which is well within easy operation, the rate of combustion is about 50 lb. per sq.ft. of grate and the evaporation per square foot of heating surface is 14.4 lb. When this is compared to three pounds, which is considered a fair figure for normal operation, it is evident the plant has been designed to carry overloads that would have been considered impossible a few years ago. To avoid difficulties with scale the makeup water is distilled. Valves in the high-pressure lines are of steel and of the gate type. In line with modern tendencies, duplex exciter units, with a motor on one end and a turbine on the other, are employed. An innovation tending to collect some of the stray heat units is the circulation of condensate for cooling the main turbine bearings.

Steam-Turbine Development

In the review last year was given a list of large turbines on order. Some of these were the 50,000-kv.-a. turbo-generator for Connors Creek, the 60,000-kw. three-cylinder unit for the Interborough, a 45,000-kw. turbine for the Narragansett Electric Lighting Co., of

Providence, and five 30,000- and 35,000-kw. machines for the Commonwealth-Edison Co. One of the 35,000-kw. units is shown in Fig. 1. The turbine is of the two-cylinder tandem-compound type, with the high-pressure element single-flow and the low-pressure element double-flow. To this list may be added a 45,000-kw. two-cylinder compound unit and a 70,000-kw. three-cylinder machine, the largest ever made, for the Duquesne Light Co., of Pittsburgh. Some of these ma-

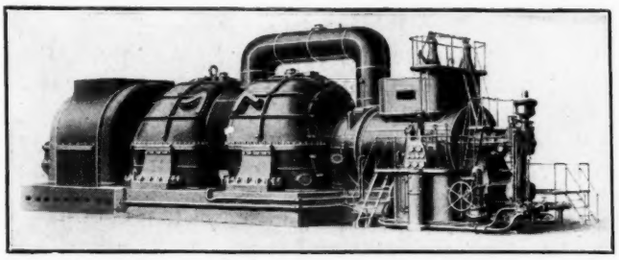


FIG. 1. WESTINGHOUSE 35,000-KW. TURBO-GENERATOR

chines have been installed and the others are still in the making. A close observance of their operation should go a long way in determining the status of the large turbine. Data will be collected that should decide the features of the various designs to be retained or modified, the best arrangement of the unit and the economical limitations.

Opinion has been expressed that the mammoth unit is perhaps after all a mistake. At least development should first come in designs for high pressure and intermediate heating of the steam to raise the average temperature. The various makers of turbines are working along different lines. Some are perfecting the impulse turbine and leaning toward a single-cylinder machine even in the largest sizes. Opposed to this is the reaction turbine with two and, in the largest machines, three cylinders. The present year should be significant in turbine development, as many great machines of either type will be placed in operation and there should be abundant data to point the way.

In the impulse turbine there is a noticeable tendency toward symmetrical cone-shaped construction, the elimination of angles and the production of a straight path for the steam. The early stages are becoming smaller in diameter and fewer to minimize the friction and leakage, which increase with the density and pressure of the steam, and better metals are being employed so that a high velocity of the blading may be maintained. The numerous control valves regulating the quantity of steam to the turbine have been replaced by a single throttle valve that for loads below normal lowers the pressure. This reduces the density of the steam and lessens the aforementioned losses without diminishing the heat content per pound. At the low end the stages are increasing in diameter to reduce the leaving loss to a minimum. In many of the late machines the length from the first to the last stage is less than the short diameter of the exhaust opening.

In the smaller units it may be stated that the turbine is rapidly replacing the reciprocating engine, even invading the small office-building plant. This is particularly true in the West. It requires comparatively small space and little attendance. There is no oil in the exhaust steam and reduction gearing permits economical speeds in different classes of work for both the prime mover and the driven machine. The turbine is even proposed for locomotive drive where with its high speed more power can be concentrated in the limited space available. The small turbine for auxiliary drive has been perfected and its economy improved. To make a combined pump or blower unit with less cost, weight and dimensions, a one-bearing turbine has been brought forth. It is incomplete in itself, but becomes an integral part of the over-all equipment.

Reciprocating Engines

Developments in the reciprocating engine have remained practically unchanged. However, the demand for marine engines has tended to accelerate the construction of this type. What is probably the most powerful rolling-mill reversing engine in existence was put in service during the year. Its cylinder sizes are 36 in. and 70 in., with a 60-in. stroke. The engine is geared and when running at its maximum speed is capable of developing more than 30,000 hp. if maximum torque occurs at the same time. However, they do not

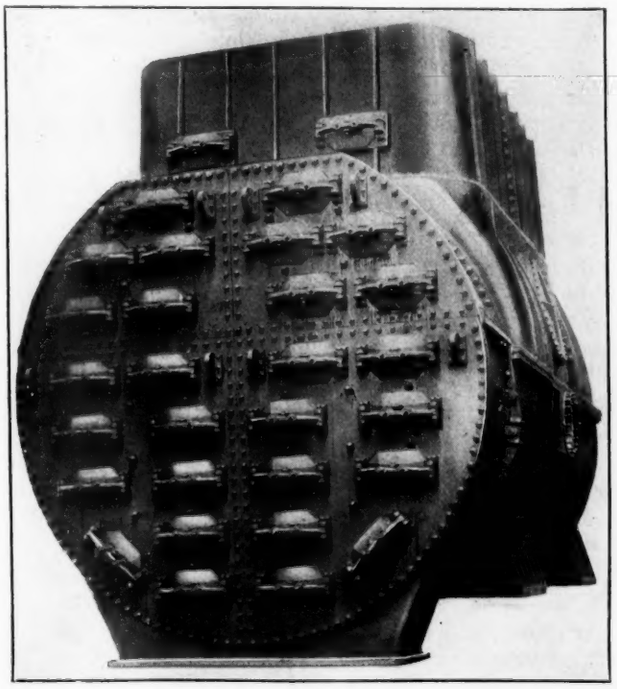


FIG. 2. WORTHINGTON SURFACE CONDENSER, 70,000 SQ.FT. OF ACTIVE TUBE SURFACE

occur at the same time and it is doubtful whether the engine will ever be called on to develop more than 11,000 hp. The approximate weight is 1,350,000 pounds.

Auxiliary Equipment

To take advantage of the low steam rates of the large turbines, the trend toward electric-driven auxiliaries has continued, steam drives, principally turbines, being maintained in lesser number to insure continuity of service and to maintain a proper heat balance. In some few cases this movement has been carried to the point of bleeding the main turbine to supplement the supply of exhaust steam to the heater. The lack of exhaust steam for feed-water heating due to the above

practice has brought about almost universal adoption of the economizer in new plants.

Manufacturers report orders for geared units as opposed to the direct-connected turbine in the ratio of three to one. In operation the gears are standing up well and have been perfected to such a point that they make little noise. An interesting development is the use of large geared units for excitation, these machines being built in capacities up to 1000 kw. In these designs the turbine may operate at its most economical speed and the generator at the low speed necessary to insure perfect commutation.

Surface condensers are naturally following the turbine and getting larger each year. Up to date 70,000 sq.ft. of active tube surface in a single shell is the largest (Fig. 2), but there appears to be no good reason why this enormous capacity could not be increased. Condensing equipments for the 60,000- to 70,000-kw. turbines for the Interborough and the Duquesne Light Co. plants are to contain 100,000 sq.ft. of surface, but it is to be disposed in four shells. Among large jet condensers the installation at Providence serving a 45,000-kw. turbine still holds the record. The outstanding feature of the year in all condensing equipment has been the unprecedented volume of business. In surface condensers there has been a tendency to increase the water pumped per pound of steam. It is also becoming apparent that, although the highest vacuum obtainable is to be desired, it should not be produced with an accompanying drop in the temperature of the condensate below that called for by the vacuum.

Some interesting developments in air pumps have been made. Maurice Leblanc, inventor of the hydraulic air pump quite universally used for turbines, has improved upon this centrifugal type by bringing forth the *multijector*. No revolving parts are employed, vacuum being produced by steam passed through a number of nozzles to give injector effect. As expected, this type takes up much less room than the well-known Leblanc air pump for like capacities. An interesting description of the *multijector*, together with recent air-pump-design progress, will appear in an early issue of *Power*.

Larger Steam Boilers

War demands have so overloaded the boiler manufacturers as to hinder and for the time being practically stop development. For the last few years there has been a gradual increase in unit size, but the growth has not kept pace with that of the turbine. In the last year, however, a boiler unit commensurate in size with the larger turbines has been developed. It is known as the Stevens-Pratt boiler, and is made up in four sections, each being a complete Babcock & Wilcox cross-drum boiler in itself, with its own superheater economizer and forced- and induced-draft fans. There are two sections on either side, the boilers being placed back to back. One stack serves the unit, and the coal- and ash-handling equipment is common to the two sections on the same side of the unit. If desired, any one or more of the sections may be operated independently. The sections are made in sizes ranging from 5000 to 14,500 sq.ft. of heating surface. Four of the largest sections operating at 400 per cent. of rating will carry 58,000 kw. This is equivalent to carrying one kilowatt on one square foot of steam-making surface as compared to four square feet at normal rating. That this arrangement is compact is evidenced by the fact that the unit occupies 7632 sq.ft. of floor space. It avoids an elaborate boiler-room building, as, with the exception of the coal bunkers, the unit is complete in itself.

Stokers and Pumps

Shortage of fuel and its increased cost has resulted in the use of coal heretofore considered unfit for burning. Anthracite screenings and coke breeze, frequently mixed with bituminous coal, have presented new problems in connection with the underfeed stoker. Naturally, the chief difficulty is to dispose of the large amounts of refuse when forcing the boilers to high capacity. Improved ash dumps are proving a solution, some operated by power and others by hand, but all designed to handle greater quantities. In addition, the underfeed stoker is being adapted to burn the high-ash Middle West coals and lignite. Some installations have already made their appearance and have been giving good results.

To burn great quantities of anthracite the duplex stoker is becoming more common. With no bridge-wall and an adjustable opening between the stokers the continuous discharge of ashes is readily accomplished. With coal fed slowly through the retorts and a great quantity carried in the furnace, conditions are favorable for high combustion efficiency. To burn more fuel from one side of the setting and obtain the high boiler ratings now in vogue, increasing the size of the retort is another alternative. Designs are now ready in which the retort area has been enlarged 50 per cent. over present standards.

On the part of several builders there have been persistent attempts to apply forced draft to a chain grate. With a moving stoker, subject to the varying density of fuel bed common with bituminous coal, the problem has proved difficult and its solution so far unsatisfactory. With anthracite more headway has been made, as evidenced by the Cox chain grate, which shows considerable promise.

In boiler-feed pumps an interesting development in the direction of compactness and simplicity is the placing of a two-stage centrifugal pump in one casing and on a common shaft with a velocity-stage turbine. The unit will serve 3000 boiler horsepower, and with one-tenth the weight occupies about one-eighth the floor space required by a duplex reciprocating pump of the same capacity.

Another interesting development given publicity during the year is the use of two centrifugal pumps driven by one turbine for economizer service. Ordinarily, the pressure in the economizer is slightly greater than in the boiler, and with the pressures increasing as they have recently, it places a serious burden on the economizer. This may be relieved by using two pumps, one taking the feed from the heater and passing it through the economizer at comparatively low pressure, the other taking the water under pressure from the economizer and forcing it into the boiler. Under such conditions even old economizers could be used with safety in conjunction with high pressures.

As the boiler pressure goes up steam velocities have been increasing. At the Joliet plant the velocity at normal load in the turbine leads is 7200 ft. per min. There are instances in which this velocity has been exceeded and velocities 50 per cent. greater have been proposed. Such practice tends to reduce pipe diameters and minimize the cost of pipe-line construction. As the density of the steam increases, friction becomes greater and there is considerable pressure drop in the pipe line, which in turn reduces the capacity of the prime mover. When these two factors have been properly correlated, it may be found advisable to spend more money for larger pipes and fittings.

The increasing cost of coal and the concentration of power in larger units has resulted in more extensive use of instruments, particularly those of the recording type, in the boiler room. New instruments and combinations of older types are constantly making their appearance, so that the fireman in these days has the advantage the engineer has enjoyed for years.

Internal-Combustion Engines

Opinion seems prevalent that there is little or no activity in the gas-engine field. In smaller sizes of engine this is undoubtedly true, but there are now in course of construction a considerable number of large

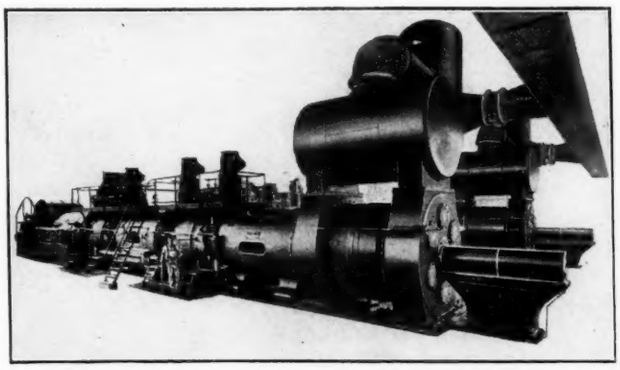


FIG. 3. MESTA TWIN-TANDEM GAS BLOWING ENGINE

gas engines for at least four of the largest steel mills in the country. Some of these engines will exceed 4000 hp. and will be used for blowing and for driving electric generators. Fig. 3, although not as large as some of the blowing engines now under construction, is a fair example of what is being done. The dimensions of this engine are 84 x 60 in. on the air end and 46 x 60 in. on the gas end. It would look as though this type of prime mover is not ready to be forced into oblivion, although the steam turbine is now pushing it hard and, owing to its economy over a wide range of load, may eventually be the favorite for steel-mill work.

Manufacturers of Diesel and other types of oil engines are working to the limit of shop capacity. Because of the high cost of fuel and the need for power by the industries, a surprising number of Diesel engines have been installed, some of them having capacities of 1000 hp. Demands for these engines in the South and Southwest still continue at an increasing rate, and on the Pacific Coast the marine field is apparently flourishing. Several firms that heretofore have built only stationary engines have lately brought out marine types. The entire output of at least two of our largest Diesel engine builders has been devoted to Government orders (for submarines) since the United States entered the war. A new design of high-compression four-cycle heavy-oil engine has been brought forth, and details of existing engines have been perfected.

Large numbers of gasoline and kerosene engines are being used by our forces in France for searchlights, portable lighting outfits, for driving compressors, for small repair outfits, etc. These are of the carburetor type, but are designed to use either gasoline or kerosene. For airplane service the "Liberty" motor has been one of the great accomplishments of the year.

Power-Plant Legislation

Legislation relative to power plants has been active throughout the year despite the war. The Boiler Code of the American Society of Mechanical Engineers is now in force or about to be enforced in the following states: California, Ohio, Michigan, Wisconsin, Minnesota, Indiana, Pennsylvania, New York and New Jersey. Many other state legislatures favorably regard the Code; but other more pressing legislation or lack of financial resources prevented the adoption of the Code in these states.

The Municipal Regulations Committee of the American Society of Refrigerating Engineers has made favorable progress in the formulation of a safety code for refrigerating plants and by December, 1918, will likely hand to the society a finished code. The City of Troy, N. Y., now enforces a code drawn up with the assistance of this committee.

There has been little activity in the enactment of engineers' and firemen's license laws. The rules of the Board of Supervising Inspectors of Steam Vessels have been modified for the purpose of facilitating the entrance of men into marine service, particularly under the Shipping Board, though there are, it seems, obstructionist forces at work to wholly or partly defeat the purpose. Some interesting water-power legislation may come during the present Congress.

Coal, Oil Fuel and Smoke

Up to the end of September the bituminous-coal production for the country exceeded that for a corresponding period in 1916 by 10.5 per cent. This increase has been approximately maintained up to the end of the year, and it means about 50 million tons in excess of the 500 million produced in the previous year. More anthracite also has been mined, but notwithstanding this immense production there has been a decided shortage of fuel. Its delivery, depending upon congested railway facilities, was irregular, and to shorten the haul many users were obliged to accept the coal nearest at hand. Owing to the higher prices attempts were made to use in part inferior grades of fuel, such as culm, coke breeze and lignites, with varying degrees of success. The uncertain conditions caused many fuel users to consider storage, laying up a supply during the summer months when the demand is lightest and transportation at its best, to tide them over irregular deliveries during the heating season. In the last year, then, more than ordinary attention has been given to coal-handling apparatus, storage and the weathering

of coal. Federal fuel administrators are doing everything in their power to encourage economy. It is realized that up-to-date firing methods and general improvement in operating conditions will save millions of tons of coal per year.

Oil fuel for power plants has come into extensive use even in New England, where under ordinary conditions it would not be considered. This has been due to the upsetting of transportation by rail and by water, the excessive cost of coal and its actual scarcity. In the year just closed the production was considerably in excess of that of 1916, which was 292,300,000 bbl., the greatest record in the history of petroleum.

Smoke abatement has been set back temporarily. The smoke in Chicago was never worse. New York is receiving its baptism of soot and ash from the burning of soft coal in furnaces designed for anthracite. Boston is in much the same situation, and even in Pittsburgh, where smokeless history has been made in recent years, conditions are not up to standard. Naturally, this is due to changes of fuel, the burning of inferior grades and the calling into service of boilers that have not been remodeled for smokeless operation. With the gradual readjustments that economy will demand the smoke situation will undoubtedly improve.

The Refrigeration Field

Perhaps the most noteworthy progress in the refrigeration field during the year is the wide adoption of the high-speed compressor, using the thin-plate valve, or feather valve. One large and oldest company manufacturing refrigerating machinery has been turning out many high-speed compressors, not an order for a slow-speed machine having been received during the first half of its fiscal year. Other manufacturers are experiencing similar business orders in relation to the high-speed compressor.

Electric drive, particularly for compressors used for ice making, is receiving ever-widening application, especially in Chicago and New York.

The new refrigerating plant of the Merchants Refrigerating Co., New York, is of unusual interest. The compressors are of the York, three-cylinder, single-acting, piston valve, inclosed type, driven by synchronous motors of special design. The efficiency of these motors is stated to be 90 to 94 per cent., the starting torque 35 per cent. and the "pull-in" torque 30 per cent.

The installation has four units, a 50-ton (234 r.p.m.), a 100-ton and two 200-ton, the three latter running at 209 r.p.m. They are to be operated at 3 lb. back pressure and 155 lb. condenser pressure. They will operate compounded; that is, two cylinders of each machine will take in low-pressure gas and the other cylinder of the compressor will take this gas and boost it to the condenser pressure. After leaving the receivers, the liquid will go to a double-pipe cooler, where water will take out the sensible heat to within 1 deg. F. of the initial water temperature. The liquid then will go to accumulators, where its temperature will be reduced to the boiling point at the intermediate ammonia pressure. The vapor will be taken directly into the high-pressure cylinder. The piping is so arranged as to permit of operating either single or compound compression. All shells, including those of brine coolers, shell condensers, etc., are autogenous (oxyactylene) welded. A more complete description of the plant will, it is hoped, soon appear in *Power*.

The booster compressor is exciting much comment, and the Ninth Street Terminal, Chicago, is a new and interesting installation. The plant has but recently been started, and performance data are not yet available. The new installation at the Consumers Ice Co., Chicago, is one of the first of the D. I. Davis low-temperature compression systems. A description of this plant is now ready for appearance in *Power*.

Welding, of course, continues to be of keen interest to refrigerating engineers, and it is cheering that all the various interests have formed the National Welding Council, which so far has displayed a most sincere and unprejudiced attitude in its aim to make autogenous welding safe for pressure vessels.

The first section of the American Society of Refrigerating Engineers has been instituted in New York City, and its success will probably lead to the organization of other sections in the large cities.

The Water-Power Situation

Although the unfortunate condition of water-power legislation still remains unsettled, there has been considerable activity in the construction of new plants and extensions to existing installations. The Copco,

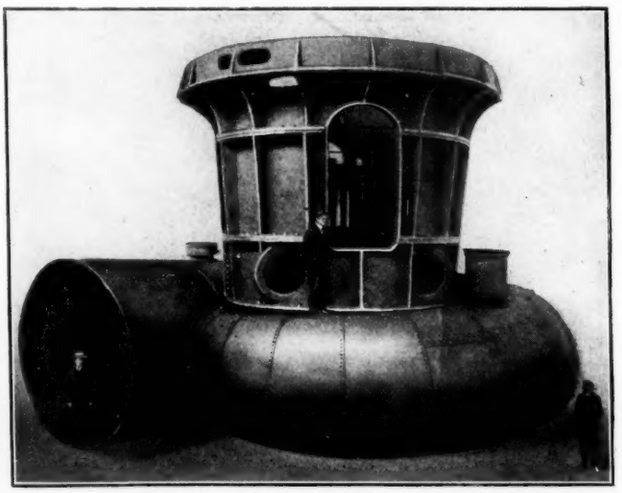


FIG. 4. S. MORGAN SMITH PIT LINER AND SCROLL FOR 16,500-HP. VERTICAL-SHAFT TURBINE

California, plant for the Southern Pacific is nearing completion. It will have an initial capacity of 25,000 hp., which later will be increased to 50,000 hp. by a subsidiary station. The Southern California Edison Co. has announced that it will shortly add 42,500 hp. to its capacity at Big Creek and make further additions to the plants served by Huntington Lake.

The Puget Sound Traction, Light and Power Co., is installing 25,000 hp. additional capacity in its White River Power Plant near Sumner, Wash. The Montana Power Co. is installing four 16,500-hp. single-runner vertical-shaft Francis type turbines in its Holter plant. The steel-plate scroll, the intake diameter of which is 12 ft., and cast-iron pit liner for one of these units are shown in Fig. 4. These machines will operate under a working head of 109 ft. and run at 150 revolutions per minute.

Work has continued on the 31,000-hp. single-runner vertical turbines for the Yadkin River development in

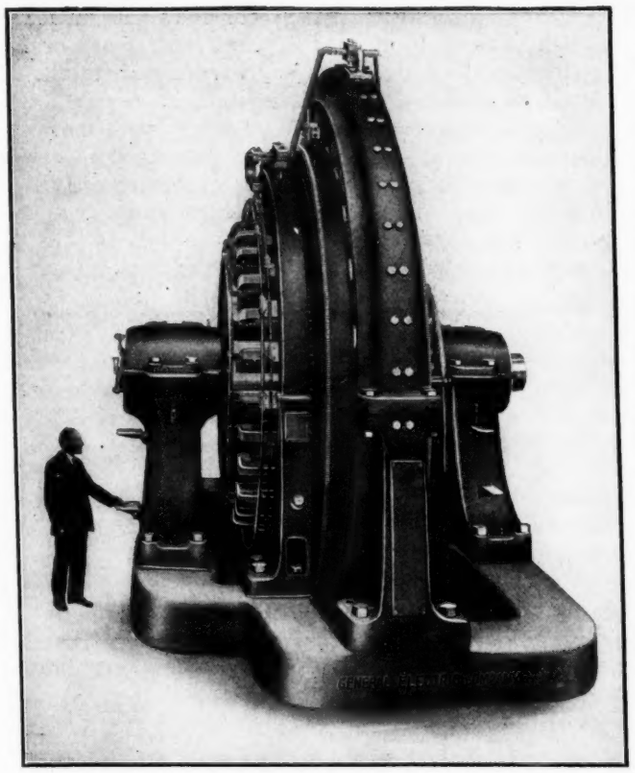


FIG. 5. GENERAL ELECTRIC 6825-KW. 25-CYCLE ROTARY CONVERTER

North Carolina, and numerous other large installations might be mentioned. Owing to the great power demands and the higher cost of fuel, several hundred thousand horsepower has been added to "white-coal" capacity during the year. In the way of improvements may be mentioned simplification and standardization of governors, development in runner design and reduction of hydraulic losses in intake and draft tubes.

Acquisition of the properties of the Ontario Power Co. by the Hydro-Electric Commission of Ontario was a significant step toward governmental participation in developing natural resources. When the Chippewa Creek-Queenstown Heights developments are completed, the commission will be the largest producer of water power in the world. Its work will be watched with interest in this country, as the adoption of a similar plan may be the solution for the existing controversy in this field.

Electrical Development

During the last year there has not been any marked change in the electrical industry over that of 1916. The manufacturers have been practically overwhelmed in trying to meet the demands on the industry for standard equipment, consequently the development of new types of machinery has been subordinated to these demands. However, a number of the large machines that were projected in 1916 were built and installed during 1917. Others again are still in the construction stage, as pointed out in the foregoing, in reference to the large turbine unit.

During the year 25-cycle rotary converters up to 6825-kw. capacity, Fig. 5, have been put in operation, and 60-cycle machines up to 5800 kw. in size have been installed. These machines are the largest of either type that have so far been built. One of the most important advances in the construction of self-controlled induction feeder voltage regulators is the 600-kv.-a. three-phase 60-cycle 13,200-volt unit, Fig. 6, installed by the Southern Power Co., to be connected to the low-voltage side of a 6000-kv.-a. bank of 44,000- to 13,200-volt transformers. This unit is equipped with radiators on the tank for cooling purposes similar to those used on self-cooled transformers.

The most interesting transformer unit of the year is probably the 44,000-volt to 6000-volt, 8000-kv.-a. oil-insulated self-cooled unit, Fig. 7, six of which were built for the Carnegie Steel Co. The radiators are constructed of a number of vertical flattened tubes welded into headers, which are flanged and bolted to the tank. The 24 radiators on each tank give an effective cooling surface of approximately 1,000,000 sq.in. Oil-insulated water-cooled units of over three times the foregoing capacity are under construction or being installed.

The Pacific Light and Power Co. has installed in its Eagle Rock substation at the end of a transmission line 241 miles long, a 15,000-kv.-a. synchronous condenser, Fig. 8. This is used to maintain constant voltage at the receiving end of this long transmission line, which is operated at 135,000 volts with grounded neutral at the power-house end. Before the condenser was installed, the no-load voltage at the receiving end was 211,000 volts. With the condenser in service the voltage at the receiving end of the transmission line is held practically constant under all conditions of load.

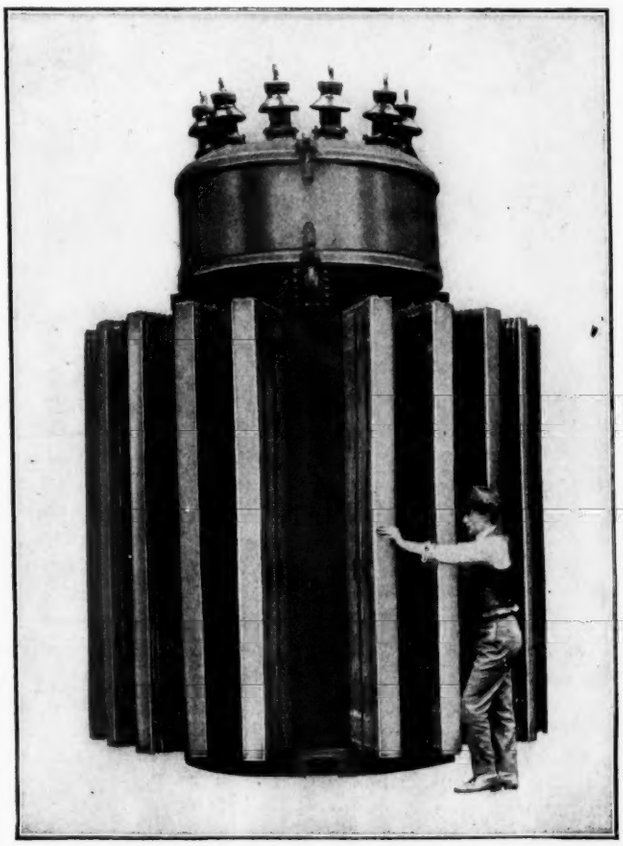


FIG. 6. WESTINGHOUSE 600-KV.-A. 3-PHASE INDUCTION FEEDER VOLTAGE REGULATOR

In the steel industry the application of electricity has continued to make rapid advances. Two of the chief applications are of reversing motors for rolling-mill main-roll drives and the electric furnace. There is in use at the present time approximately 690,000 hp. of main-roll drives in the United States, an increase of 400 per cent. during the last five years. These drives require very large motors. The reversing blooming-mill unit shown in Fig. 9 is one of the largest direct-current single-unit motors that has so far been built. It has a momentary rating of 10,000 hp. at 40 r.p.m. The machine is fully compensated and is shunt-wound. In spite of its great size, it can be accelerated at the rate of 50 revolutions per second. The motor is supplied with power from a flywheel motor-generator set, consisting of a 2000-kw., 500-volt generator, driven by a 2200-volt 2000-hp. induction motor. The flywheel weighs 100,000 pounds.

The vast increase in the use of electrical furnaces is evidenced by the fact that in this country, Jan. 1, 1916, there were 36 furnaces in use, having a capacity of 191 net tons, and requiring 90,000 kv.-a. At the present time the capacity has increased to approximately 1000 net tons requiring about 230,000 kilovolt-amperes.

The 250,000-kw. totalizing graphic meter, Fig. 10, built for the Keokuk plant of the Mississippi River Power Co., is the largest meter ever constructed. The instrument will give a graphic record of the output of the thirty 3-phase, 7500-kw. generators to be installed ultimately in this plant. To accomplish this thirty polyphase-meter elements, each made up of two single-phase units are used. The induction type of

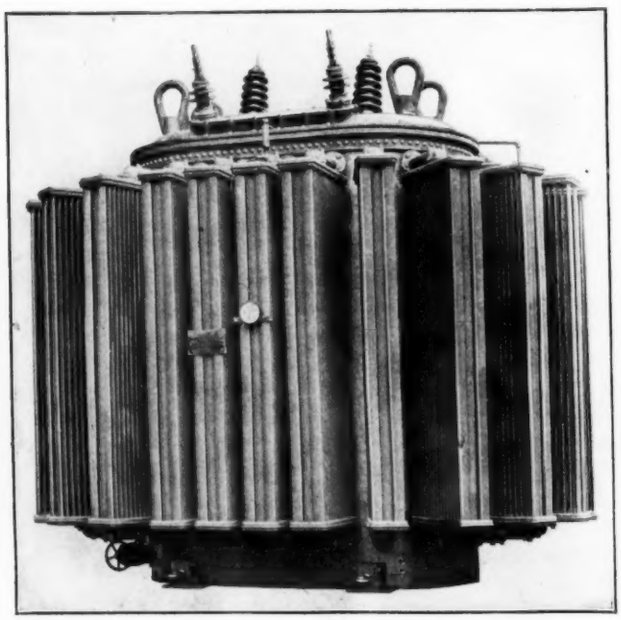


FIG. 7. GENERAL ELECTRIC 6000-KV.-A. OIL-INSULATED SELF-COOLED TRANSFORMER

meter element is employed. The moving element consists of six aluminum vanes, all supported on a single shaft. All connections are carried to the top of the instrument to a circular terminal board having 240 binding posts. The chart is 12½ in. wide and printed in 12-hour sections and feeds at the rate of 3 in. per hour.

Owing to the expansion of our industries, much of which came suddenly and is considered more or less temporary, there has been a great increase in the demand for power. Generating equipment, except on long deliveries, was almost impossible to get, with the result that the central station has been swamped in trying to supply a considerable portion of the excess power requirements. With the manufacturer it has not been so much a question of cost as obtaining quickly the power he needed to turn out war products. There is

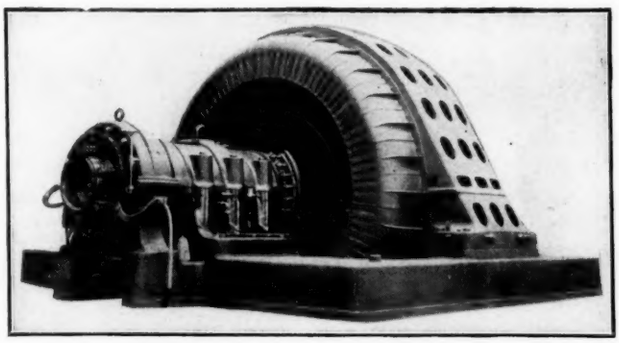


FIG. 8. WESTINGHOUSE 15,000-KV.-A. SYNCHRONOUS CONDENSER

still a great deficiency in prime-mover capacity, and to improve this condition it has been suggested that private plants tie in with the central station, helping it out on the peak load and in turn taking current from it in the valleys, but standing by as reserve capacity needed in case of breakdown.

Shortage of coal has aggravated the situation. It has instigated a great campaign for saving. By state fuel administrators, committees have been appointed to investigate the possibilities and to interest owners of private plants in this movement. The fireman is being flooded with instructions, and publicity committees are arranging for space in the press and competent lecturers, preferably engineers, to point out the many possibilities of saving in the private plant and the home.

Increase in the price of coal tends to enforce better economy in all stations, private and central. To meet the great demand for power and for economy in the use of coal it would appear that the time is ripe for readjustment. There is many a private plant taken over by the central station that could be operated more economically on its own basis. It could produce the power, light and heat needed with an expenditure of coal less than the independent electric and heating services now require. There are some private plants of which the reverse is true. The exigencies demand careful, unbiased analyses to determine in each case what is best for the common good.

Engineering Societies

The campaign that has been conducted for the last few years showing the need and the desirability of coöperation among engineers is at last bearing fruit. The demands of the war have hastened the movement. The Engineering Council of the United Engineering Society has recently come into being as a medium of coöperation between the four big national engineering societies. It is made up of five members from each body and four from the parent organization. The

council has authority to speak on all questions of concern to engineers. Realizing that at present the big thing is war work, the council has organized a "War Committee of Technical Societies," which has been coöperating in every way possible with the Government. The American Boiler Manufacturers' Association has appointed a war-service committee to act as a point of contact between the industry and the Government, and practically every engineering association in the country has offered its services in one way or another.

Coöperation between the local sections of the various societies is also improving. Joint meetings, dinners and entertainments are becoming the rule. In this connection it might be added that plans are on foot for a building to house all engineering societies in Chicago. This in reality is to be an engineering headquarters second only to New York.

The American Society of Mechanical Engineers continues to conduct work of inestimable value to the field. The Boiler Code, now adopted by nine states and four cities, is being perfected and interpretations are sent monthly. The safety-valve regulations are in process of revamping, and the question of welding is receiving attention. In its visit to the Chicago section, the Council has initiated a practice contributing toward the nationalization of the society by eradicating the too-prevalent idea that much of the benefit of membership centers in New York. These visits are worth continuing.

A progressive step by the National Association of Stationary Engineers at its last annual convention was the setting aside of definite periods for welfare talks by the delegates dealing with their work and improvement of the organization. The society is devoted primarily to education, but heretofore much of the

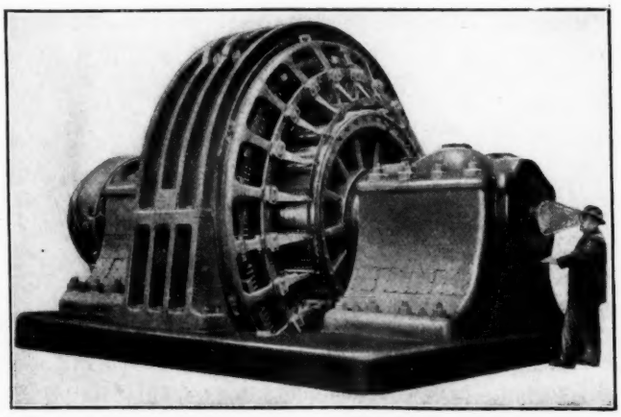


FIG. 9. GENERAL ELECTRIC 10,000-HP. DIRECT-CURRENT, REVERSING BLOOMING-MILL MOTOR

national convention has been taken up by routine business. The innovation was heartily approved, and it is safe to predict that each year will see more of the time of the convention given over to the watchword of the association.

THE HONOR ROLL FOR 1917

For 1917 the honor roll is long and it is made up mostly by engineers engaged in the war, some in important work at home and others at the front. Of the latter many have already shown that they deserve high places in the list. For engineering achievement in private work mention should be made of Nikola Tesla, awarded the Edison Medal for original work in polyphase and high-frequency electric currents. Dr. Henry Marion Howe received the John Fritz medal for his investigations in metallurgy, especially in the metallography of iron and steel. Five gold medals were awarded by the American Museum of Safety for noteworthy achievement in the realm of safety.

Engineering societies closely related to the field honored the following men by election to the presidencies: Charles Thomas Main, American Society of Mechanical Engineers; E. W. Rice, Jr., American Institute of Electrical Engineers; J. W. Lieb, National Electric Light Association; John A. Wickert, National Association of Stationary Engineers; Ezra Frick, American Society of Refrigerating Engineers; Irwine J. Lyle, American Society of Heating and Ventilating Engineers; G. W. Martin, National District Heating Association.

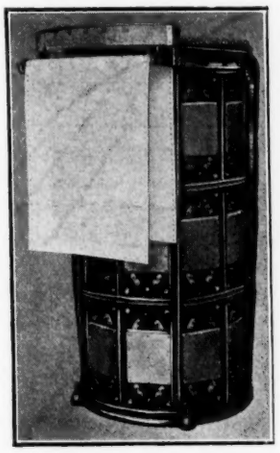


FIG. 10. ESTERLINE TOTALIZING GRAPHIC METER

NECROLOGY

It is pleasing to report that men of prominence in the field who passed away during the year were few in number. The columns of *Power* record the following: Alfred Blunt Jenkins, of Jenkins Brothers; Henry Gordon Stott, superintendent of motive power of the Interborough Rapid Transit Co.; George Ross, president of the Ross Valve Manufacturing Co.; James Terry, president of the Terry Steam Turbine Co.; Frank Lewis Bigelow, president of the Bigelow Co.; William G. Bee, vice president and general sales manager of the Edison Storage Battery Co.; James Fulton Cummings, an electrical engineer of international reputation; Albert F. Ganz, professor of electrical engineering at Stevens Institute of Technology; Arthur Kneisel, treasurer of the American Association of Engineers; Royal C. Peabody, president of the Combustion Engineering Co.; William P. Hancock, superintendent of the generating department of the Edison Electric Illuminating Co. of Boston; James F. Meagher, former president of the People's Gas, Light and Coke Co., of Chicago; George Harrison Klumph, late Western manager of the Green Fuel Economizer Co.; William D. Kearfott, president of the Kearfott Engineering Co.; Benjamin Murray Plumber, president of the Main Belting Company; Joseph F. Chuse, founder and manager of the Chuse Engine and Manufacturing Co.; Thomas Eugene Byrne, vice president and chief engineer of the Kings County Lighting Co., Brooklyn, N. Y.

Petroleum residual oil as fuel for Diesel engines is so scarce in the British Isles that users have had to adopt tar oil. They were just getting along nicely when the Minister of Munitions up and restricted the use of tar and other oils. And yet the "business as usual" howlers say there is plenty of fuel of all kinds.

New Method of Increasing the Evaporation in Boilers

By CARL HERING

A new thermal principle in the boiling of water is described. The thin film of gas on the flame side of a water-boiling vessel offers an enormously high resistance to the flow of heat. By means of lugs on the flame side of surface an artificial thermal resistance is established, which greatly increases the flow of heat, provided these lugs are properly proportioned.

IT IS well known that water may be boiled in a cup made of ordinary paper; also that a postage stamp may be pasted on the flame side of a metallic vessel in which water is being boiled and although the flame plays directly upon this stamp it will not be charred. It is perhaps less well known that when a second or third stamp is pasted over the first one, the outer ones will char. If there is a blister in a single thickness of the paper, that blister will char.

Gas Film on Flame Side of Vessel

The interpretation of this is that when very hot gases, like those of a flame, impinge upon the outside surface of any water-boiling vessel, which is constantly maintained at a far lower temperature by the water on the other side of it, a thin film of gas forms on the flame side of the surface which offers an enormously high resistance to the passage of heat through it; its specific resistance appears to be far greater than that of thermal insulators, yet all the heat which flows usefully from the flame to the water must traverse it; this film is therefore a very great obstruction to the flow of heat, and this method of heating is a very irrational one, although it is the usual way. The thermal resistance of the metallic walls of the vessel is so small in comparison that there is no appreciable gain in the heat flow by using copper tubes in a boiler in place of iron ones, even though copper conducts heat much better than iron.

If the temperature of the flame is taken at about 1350 deg. C. (2462 deg. F.) and that of the water is 100 deg. C. (212 deg. F.), there is a fall of temperature of about 1250 deg. C. through this film, which appears to be only about 0.005 in. thick; this means an extremely high thermal resistance, so high that it is a question whether it is a true resistance; but as it certainly acts like one, it may at least be here referred to by this term.

If this high-resistance film could be broken down, the heat would flow more rapidly from the flame to the water, which means that the water could be boiled faster or that the boiling vessels, like steam boilers, could be made smaller for the same steaming capacity; also that the losses of heat would be reduced, for if a given quantity of water could be boiled twice as fast, for instance, with the same flame, the heat losses will be reduced to a half, as they take place during only half the time.

One way to reduce the resistance of this film is to use a blast flame, which seems to mechanically carry away part of the film; a strong blast flame directed against the aforementioned postage stamp will char it; but this method is not generally practicable. The usual way is to increase the surface exposed to the flame, but doubling or trebling this surface while using the same flame does not necessarily double or treble the heat flow; if the volume of the flame is then also doubled or trebled, the amount of boiling will, of course, be increased proportionately, but this simply means doubling or trebling the whole boiler; this increases the quantity of heat transmitted but not the rate; nor does it increase the efficiency very much.

By studying the nature and properties of this high-resistance film the writer found that its resistance diminishes very rapidly when there is less difference of temperature between its two sides; namely, between the flame and the metal. In boiling molten zinc, for instance (about 950 deg. C.), instead of water, the resistance of this film would be very greatly reduced. It is probably also very slightly less in high-pressure boilers in which the temperature of the water is higher.

It seems to be analogous to the case in mechanics in which a heavy weight struck by a sharp blow will move only slightly, but when the same energy is exerted on it less violently, the body will be moved more freely by it; the resistance of the body against being moved (due to its inertia) becomes greater as the suddenness of the blow increases. Our present method of heating water may be said to be analogous to moving a heavy car by applying sharp hammer blows at the rear, in which case its inertia acts like a high resistance; this analogy, however, is only approximate.

Establishing Artificial Thermal Resistance

As the temperature of the flame is fixed, and it would be inadvisable to reduce it, and that of the water cannot be raised, there remains only increasing the temperature of the flame side of the vessel or boiler tube. This can best be done by interposing a thermal resistance between the flame side of the vessel and the water side, such that the flame side may become far hotter than the water side, say a red heat. The writer's researches have shown that when the usual flame impinges on a surface that is artificially maintained at a very much higher temperature than boiling water, say a dull-red heat, the resistance of this film is very greatly reduced; and that the artificially added resistance required to do this is far less than that of the film was, hence there is a great reduction in the total resistance and therefore a great gain in the flow of heat. It is a curious case in which the adding of still more thermal resistance in the path of the flow of heat diminishes the total resistance greatly. In mechanics a spring may in some respects be likened to a resistance to an opposing force, yet the addition of a spring between a violent push and a heavy body helps to overcome

that effect of the inertia by which it acts like a high resistance.

These thermal relations are illustrated diagrammatically in Fig. 1. Let the vertical distances represent the thermal resistances in the path of the current of heat from flame to water, and the horizontal distances the temperatures of that side of the vessel which is exposed to the flame; that is, the side on which this film forms. The curve *a* then shows approximately how the resistance of the film diminishes as the temperature of that surface is increased.

To produce this increasing temperature on the flame surface, the added artificial resistance must be increased, as the water side always has the same temperature. The curve *b* represents approximately the respective artificial resistances which must be introduced to produce these increased temperatures. The total resistance, which is what governs the resulting flow of heat, will then be the sum of the ordinates of these two curves, giving a curve approximately like *c;* this curve shows that as more artificial resistance is introduced the total resistance falls, at first very rapidly, then reaches a minimum point and then rises again. The flow of heat will therefore first increase rapidly, reach a maximum, then fall again, showing that there is a point at which it is no longer advantageous to further increase this artificial resistance. The present researches indicate that this point seems to be reached when the temperature of that surface is about midway between that of the flame and that of the water; hence for water boiling this would be about 725 deg. C., which means a dull-red heat. This condition means that the drop of temperature in the artificial resistance is then equal to that in the film.

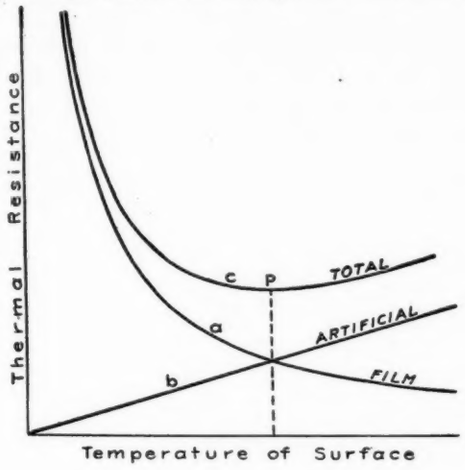


FIG. 1

FIG. 1. RELATIONS OF THERMAL RESISTANCES

A practical way to introduce this artificial resistance is by means of lugs on the flame side of the surface, which have such a length and diameter that the heat flow through them will maintain their hot ends at about a dull-red heat. In the writer's tests with lugs of the same diameter and increasing lengths, the flow of heat through them at first increased as they were made longer, and then diminished again after a certain length had been exceeded, thus corresponding to the curve *c*. When too long, their ends were at a bright-red heat.

It is an interesting and instructive experiment to solder some small nails or tacks with their heads against the outside of the bottom of a tin cup, then apply a large bunsen flame and notice how quickly and violently the water will boil directly over those nails as compared with the boiling over the rest of the surface of the cup. These lugs may be said to be a means for piercing this high-resisting film, allowing the heat to rush rapidly through these thermal openings.

The same thermal resistance may be produced by a long thick lug or by a shorter but thinner one, provided the ratio of the length to the cross-section is the same; and the quantity of heat flowing through each lug will of course diminish with its cross-section. Theoretically, therefore, the best condition would appear to be one lug of the diameter of the bottom surface of the vessel, or in other words, a very thick bottom, or very thick-walled boiler tubes. But it will be found that this thickness (corresponding to the length of the lug) would then have to be several feet, making this form of the resistance absurdly impracticable. The other extreme would be to have innumerable very thin short lugs, close together; this is impracticable on account of the expense, the frailty of such thin lugs, and the fact that when maintained at such a high temperature they gradually burn up. Between these extremes there are mean proportions which give the best results, considering the practical conditions.

Effects of Varying Spacing and Shape of Lugs

Other effects are also involved. By spacing the same size lugs farther apart, the greater freedom of the circulation of the hot gases between them was found to increase the flow of heat through each lug, but as there were then less lugs per square inch of surface, the total heat flow in the vessel as a whole was less. It appears that the film is destroyed, or at least reduced, along the lateral surfaces of these lugs also, as the gases reaching the cooler parts are themselves cooler; hence the lateral surfaces take a more important part than a mere increase of surface. And the lugs may be made slightly conical so that their bases cover practically the whole surface, while their thinner ends are far enough apart to permit the free circulation of the hot gases. When placed radially on the outside of the tubes of a water-tube boiler, they may be cylindrical yet have their cooler ends close together and their hot ends farther apart.

Many comparative tests in which the time was noted for evaporating the same quantity of water over identical flames and in identical open cups, differing only in the size, number and shape of the lugs, showed that there were some best proportions at which the heat flow was greatest, as varying the proportions in either direction gave less good results. These tests also showed very decidedly that the view generally held that a gain by the use of lugs was due to the increase of surface is entirely wrong, which no doubt explains why the frequently suggested addition of lugs and similar surface-increasing devices has not come into general use; the principle was not the correct one. It is of course true that a greater heat-receiving surface is a good feature, but it will amount to little or no gain in the rate unless the thermal resistance of the lugs is properly proportioned. In one test the lugs were made of the same length and total cross-

section, but had greatly differing surfaces by making one set very flat and the others round; those having the lesser surface actually gave decidedly the better results. The results in many tests were absolutely out of proportion to the surfaces, showing how greatly in error our former views were.

The desired condition is to have such a thermal resistance that when the flow of heat through it has become steady, the hot ends will be maintained at such a high temperature that the film resistance is greatly reduced. With the same resistance the difference of temperature at the two ends will therefore also depend on the flow of heat through it, as a large flow of heat through a low resistance may produce the same difference of temperature between the ends as a small flow through a high resistance; it is quite parallel to the electrical analogy. The proportions, moreover, are different for iron and for copper lugs. It is therefore not only a question of the resistance alone, but also of the resulting flow of heat; the problem of finding the best proportions is therefore not as simple as might at first appear, and the conclusions drawn from experiments must be carefully interpreted or they may mislead.

For instance, a thin coating of enamel or of some asbestos compound might be used as the artificial thermal resistance, but owing to its high specific resistance a very small heat flow through it would suffice to raise the temperature of the outside high enough to break down the film resistance; but as it is a large heat flow that is wanted, the artificial resistance should be made of as good a conductor as possible in order that it may require as large a flow of heat as possible to bring about this film-breaking temperature; the larger this heat flow, the lower need this artificial resistance be.

Results of Tests by Others

During the earlier stages of the writer's researches some disinterested parties conducted some carefully made tests in which water was heated by the gas flames of ordinary cooking stoves in open vessels with various kinds of lugs, the amount of gas and its calorific value being determined; their best results were that the same quantity of water could thus be heated about twice as fast with about half the gas; since then the writer has obtained considerably better results.

Referring to Fig. 2, with lugs of the same diameter and of different lengths, as 2, 3 and 4, regularly spaced, the relative flows of heat through a lug were approximately those indicated by the vertical lines above them, that for 1 being the flow through an equal area of the bottom without any lug, therefore representing the normal practice of today. It will be noticed that for the greatest length, 4, the flow again became less, showing that the best length had been exceeded.

In Fig. 3 the lengths of all the lugs are the same, but their diameters are diminished. The vertical lines in this case represent the relative heat flows per unit cross-section of the lugs; lug 4 was the same as 3 in Fig. 2. Here again the last one, 6, showed that the best proportions had been passed.

In ordinary boiler practice the normal heat flow is generally given as three pounds evaporated per square foot of heating surface per hour, though this is sometimes exceeded, being said to be as high as 16 in some locomotive boilers, though probably at a considerable sacrifice of thermal efficiency.

The writer's researches were made in open, flat-bottomed tin cups, each having on its bottom a set of regularly spaced equal lugs, the proportions of the lugs being different for each cup, the one without any lugs being taken as the zero of reference. The same quantity of water was evaporated in each, with the same large though quiet bunsen flame, and the time was noted. Reduced to pounds per square foot per hour, some of the many results were as follows:

In the cup without lugs the heat flow corresponded to the evaporaton of about 17 lb. per sq.ft. per hour. This and not three pounds should be taken as the basis of the comparison with the lugs.

This rate being allowed for the portion of the bottom which is between the lugs, the rate through the lugs themselves was as high as 467 lb. per sq.ft. per hour, showing how the heat rushes through the thermal openings in this film made by the lugs when they are properly proportioned; this rate is about 27 times that for

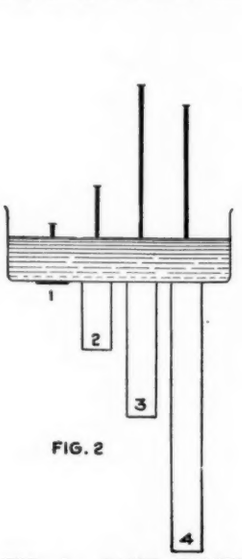


FIG. 2

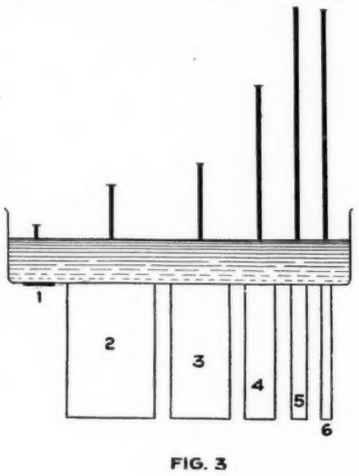


FIG. 3

FIG. 2. SAME DIAMETER AND DIFFERENT LENGTHS.
FIG. 3. SAME LENGTHS AND DIFFERENT DIAMETERS; FLOW PER SQUARE INCH SECTION

the cup without lugs, hence surprisingly great; the spheroidal state, which limits this rate, was not yet reached. The film resistance had then been reduced in effect to about two per cent. of what it was originally.

This shows how very much greater the heat flow through the properly proportioned lugs is as compared with the flow through an equal surface without lugs, and therefore how very greatly the resistance of this film in ordinary practice cuts down the transference of the heat to the water. In that particular test the lugs were spaced rather far apart, in order to find out what might be expected per lug when the hot gases have free circulation around them, and it is therefore of interest only in showing the possibilities and the correctness of the principle. This extremely high rate might perhaps be approached, say half way, in practice in the case of small-diameter boiler tubes in which the cooler ends of the lugs are as close together as possible and the hot ends far apart; but these lugs were rather too slender and numerous for practical purposes, except perhaps for very small boilers or water heaters.

With the same size lugs but spaced much closer together, thus getting less flow of heat per lug but more per square inch of total surface of the whole bottom, the result was about 60 lb. per sq.ft. per hour for the total bottom of the cup, which is still about 3½ times as great as for the cup without lugs.

These lugs were perhaps too slender and numerous for large boilers in regular practice, though perhaps not so for cooking utensils. Making the lugs four times as large in cross-section and using less than a third as many, the result was about 55 lb., hence only slightly less and still about 3¼ times that for the ordinary surface.

These results, surprising as they are, could no doubt be still further improved by further researches in this direction. There are other factors which also increase the heat flow, such as ending the lugs in points or edges, making them conical, etc.; moreover, heat seems to flow more readily from copper to iron than the reverse or than from iron to iron, hence copper lugs on iron vessels may give improved results; a moderate blast against the lugs also seems to have a greater effect than against a plane surface.

But even if in boiler practice and for cooking utensils, hot-water heaters, etc., the present rate could be only doubled, it would still mean that the same size of boiler would generate steam twice as fast and probably with even a slight gain in heat efficiency, and for household cooking utensils used with gas stoves it would mean heating twice as fast with half the gas. The bottom of the cooking utensils can be cast with the lugs, and in steam boilers the lugs can be electrically welded to the tubes, hence neither involve anything impracticable or costly.

Nugent Gravity Filter for Large Plants

In designing this oil filter accessibility and efficiency were the leading aims. Any part of the filter may be opened quickly for inspection, cleaning or repairs. The principle of operation is the same as that of the circular filter described in the Mar. 30, 1915, issue of *Power*. The new filter, which is square in section, is for large work, and can be made in capacities to filter 100 gal. per hour up to any size required.

Oil to be filtered enters through the inlet *A*, or it may be poured in by hand by lifting the lid to the screen chamber *K*. The oil flows through the special filtering material located between two vertical screens *R* in the top chamber and down through the pipes *L* into the settling and water-separating chamber. The latter is fitted with a steam-heating coil *G*, which runs around all four sides, also with lids to provide for inspection and cleaning while filtering is in process.

From this chamber the water flows up through a baffle box *O* and finally out through the discharge pipe *E*, as indicated by the arrows. This pipe is fitted with the observation fixture shown in either view. The oil rises in the settling chamber and overflows into the pipe *N*, passing down to the distributing header *P*, from which it is fed through stop-cocks to the filter bags. The header has caps at each end outside the filter, their removal facilitating inspection or cleaning.

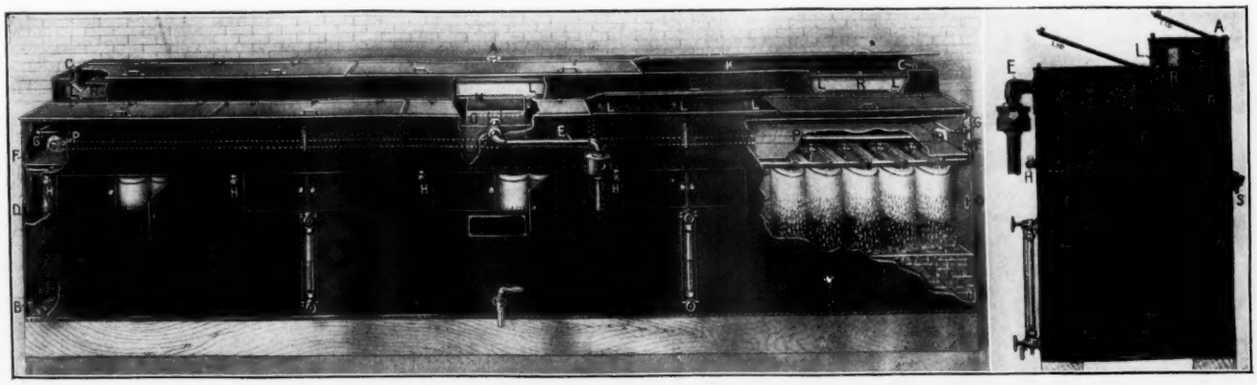
The filter bags are oval in shape and are hung side by side on racks. Any set may be lifted out through the front door without disturbing the others. The bags are made of special filtering cloth. They cannot touch each other when full, nor can the contents overflow into the clean oil below, any excess being discharged into the outside troughs. Incandescent lamps placed at *H* illuminate the bag chamber.

The clean oil is drawn off at *B*, dirty oil and water at *C* and the clean oil overflows at *D*. Outlet *F* drains the settling chamber when repairs are necessary. The capacity of the filter shown is 500 gal. per hour, but, as previously stated, any size can be furnished from 100 gal. per hour up. William W. Nugent & Co., Chicago, Ill., are the makers.

Power Plant Burns Locomotive Cinders

The new power house of the large railroad station that has just been completed at Frankfort on the Main, Germany, despite the difficulties due to the scarcity of labor and material, is the first large railroad power station in the world to be operated entirely on the cinders taken from the locomotive. These cinders, according to the *Frankfurter Zeitung*, are piled in heaps from which an electric traveling crane runs directly to the boiler room.

Three boilers of 250 sq.m. (2691 sq.ft.) heating surface are fired by automatic underfeed stokers. Cinders alone or mixed with coal dust are used with a value of about 13,800 B.t.u. The steam is used to drive two turbines of 2000 hp. each, which generate current for the entire lighting and power equipment of the station. The foundation for a third turbine of the same capacity has been put in for future expansion.



FRONT AND END VIEW OF GRAVITY FILTER FOR LARGE POWER PLANTS

The Electrical Study Course—Elementary Single-Coil Dynamo

It is shown in this lesson how, when a coil of wire is revolved between the poles of a magnet, it has an alternating electromotive force induced in it and how this alternating voltage may be changed into a direct potential in the external circuit by means of a divided ring.

THE windings on the armature of a generator consist of a series of loops or coils grouped in various ways, depending upon the type of machine, voltage, etc. The simplest form would be one loop arranged to revolve between the north and the south pole of the magnet, as shown in Fig. 1. The ends of the loop connect to the rings R_1 and R_2, with brushes B_1 and B_2, resting on the latter to form a rubbing contact between the revolving loop and the stationary external circuit C. Considering the loop to revolve in a clockwise direction, as indicated by the curved arrow, the side of the loop under the N pole will be moving downward while the side under the S pole will be moving upward. The lines of force are from the N to the S pole; therefore, by applying the rule for the direction of the electromotive force generated in a conductor cutting lines of force, it will be found to be as given by the arrows on the two sides of the loop, which is away from the reader under the N pole and toward the reader under the S pole. This is just as it should be, since the lines of force are in the same direction under each pole, but the direction of the conductor under one pole is opposite to that under the other.

Factors Governing Value of the Voltage

By tracing around through the loop it will be seen that the e.m.f. generated in the side under one pole is added to that under the other pole. Or, in other words, we have the same condition as when two voltaic cells are connected in series, and if two volts are generated in one conductor, the two conductors in series will generate four volts. Hence, it is seen that one of the factors which govern the voltage of a given generator would be the number of conductors connected in series. For example, if instead of only one turn in the coil, as in Fig. 1, we have two turns in series, as in Fig. 2, and if the coil is revolved at the same rate and the magnetic density the same in both cases, then each conductor under a pole will have equal voltage generated in it. Again, by tracing through the coil, it will be seen that four conductors are in series; consequently, the voltage generated in the coil will be four times that in one conductor, or in other words the voltage increases as the number of turns in the coil is increased.

Another way to increase the voltage would be to increase the speed of the coil; that is, if the number of revolutions per minute made by the coil was doubled, the number of lines of force cut by each conductor would be doubled. Consequently, the voltage would be increased by two. A third way that the voltage generated in the coil may be varied is by changing the number of lines of force in the magnetic field. If the speed of the coil remains constant, but the strength of the magnetic field is doubled, then double the number of lines of force will be cut in a given time. The latter is the one way usually employed for varying the voltage of all modern generators and will be treated in a future lesson.

Current Reverses in External Circuit

In Fig. 1 the flow of the current is from conductor a to ring R_2 and brush B_2 through the external circuit C and back to brush B_1 and ring R_1 and back into conductor b, thus completing the circuit. When the coil has made one-half revolution, as shown in Fig. 3, conductor a will be under the N pole and conductor b under the S pole, as shown, with the result that the direction of the voltage generated in the two conductors is reversed. The direction of the e.m.f. in conductor a, Fig. 1, is toward the reader, but in Fig. 3 it is away; in b, Fig. 1, the direction is away from, while in Fig. 3 it is toward the reader. The result of this change in direction of the voltage in the coil is a change in direction of the current in the external circuit, as indicated by the arrowheads. From this it will be seen that on one-half of the revolution the current is flowing through the circuit in an opposite direction to that on the other half of the revolution; that is, the current is caused to flow back and forced through the circuit. If the voltage in the armature conductors change in direction as they pass alternate north and south poles there must be some position where the voltage is zero; this is indicated in Fig. 4.

When the coil is in the position shown in Fig. 4, it is moving parallel with the lines of force and is therefore not cutting them, and consequently not producing any voltage. From this point the voltage increases until the conductors are at the center of the polepieces, where they are moving at right angles to the lines of force and are therefore cutting the flux at a maximum rate, consequently producing a maximum pressure. For the next quarter of a revolution the voltage decreases to zero.

Electromotive Force or Current Curve

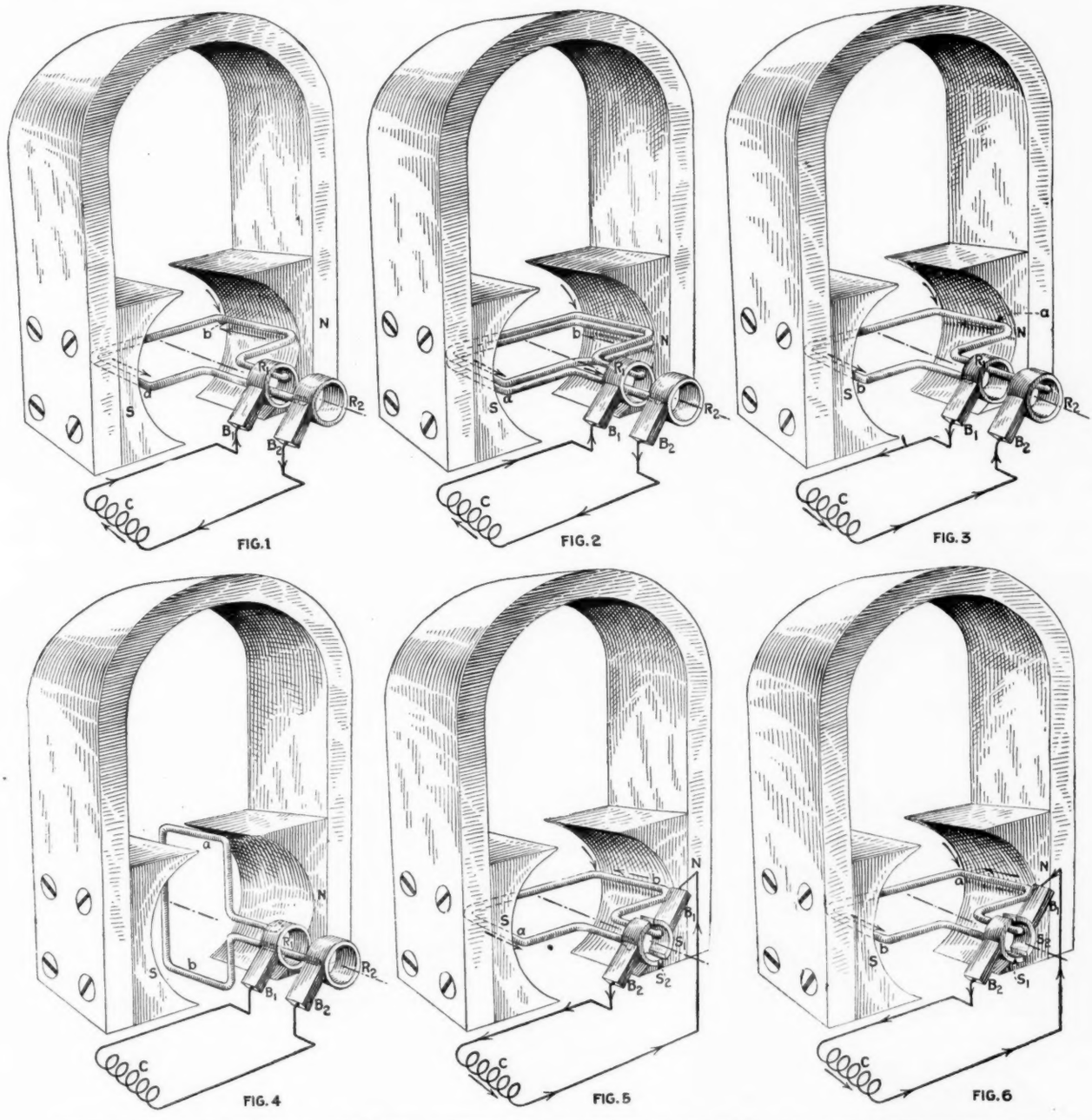
The series of values that the voltage or current passes through in the coil during one revolution may be expressed in the form of a curve, Fig. 7. The distance along the straight line between the two zero points of one curve represents the time required by the coil to pass the pole faces, or in Figs. 1 to 4, to make one-half revolution. The vertical distance between the line and the curve at any point represents the value of the voltage or current in the coil at that instance. The curve above the line represents current or voltage in one direction, while the curve below the line represents current or voltage in the opposite direction. A current or electromotive force that changes in direction in the circuit as shown in the foregoing is called an alternating current or electromotive force.

The voltage generated in the armature of all commer-

cial types of generators is alternating, no matter whether the current in the external circuit flows in one direction or is alternating back and forth. If we want the current to flow in one direction in the external circuit, or, as it is usually called, a direct current or continuous current, some means must be provided to change the alternating voltage generated in the armature coil to one that is always in the same direction in the external circuit.

In Fig. 5 is shown a scheme that will maintain the voltage in one direction in the external circuit. Instead of the ends of the coils connecting to two rings, as in Figs. 1 to 4, they connect to the two halves of a divided ring. In the coil position shown, brush B_1 rest on segment S_1 and the current in the external circuit is in the direction indicated. When the coil has revolved a half-revolution as in Fig. 6, brush B_1 is resting on segment S_2, and although the current has reversed in the coil from that in Fig. 5, it is maintained in the same direction in the external circuit, as indicated by the arrowheads.

Although the voltage is applied in one direction to the external circuit, the current will not be of a constant value on account of the varying value of the voltage. What will be obtained is a current that flows in waves, as shown in Fig. 8 and is known as a pulsating current. To obtain a constant current for a given value of resistance in the external circuit, or, as it is usually called, a direct current, it is necessary to have a number of coils on the armature and the ring divided into as many sections as there are coils. This will form the subject of a future lesson.



FIGS. 1 TO 6. ELEMENTARY ELECTRIC GENERATOR, CONSISTING OF ONE COIL AND HORSESHOE MAGNET

Fig. 9 shows the layout of the study problem given in the last lesson. The conductors from the source of power will have to be large enough to transmit a current $I = I_1 + I_2 = 150 + 125 = 275$ amperes. Referring to the wire table, it will be found that a 300,000-cir.mil, rubber-covered conductor is required for 275-amp. load. Between the first and second load, the conductors need only be large enough to take care of 125 amperes

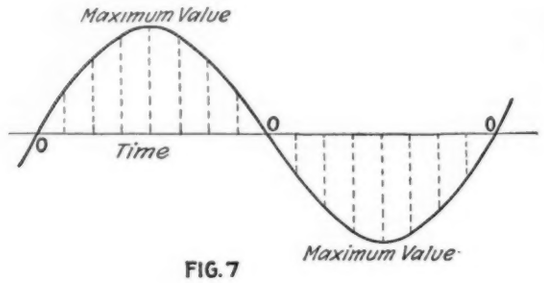


FIG. 7

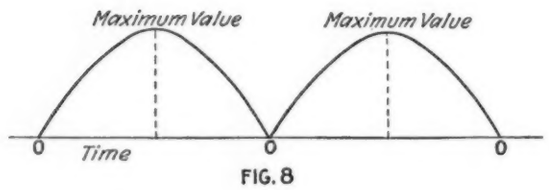


FIG. 8

FIGS. 7 AND 8. VOLTAGE OR CURRENT CURVES

and according to the wire cable, a No. 0 wire may be used. The resistance of the circuit from the source of power to the first load is that of 700 ft. of 300,000-cir.mil conductor, which is $R = \frac{10.7L}{cir.mils} = \frac{10.7 \times 700}{300{,}000}$ = 0.025 ohm. Volts drop in this part of the circuit is $E_d = RI = 0.025 \times 275 = 6.875$ volts, and the voltage available at this load is $E_a = E - E_d = 240 - 6.875$

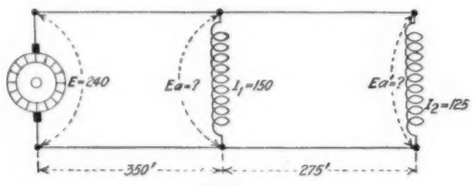


FIG. 9

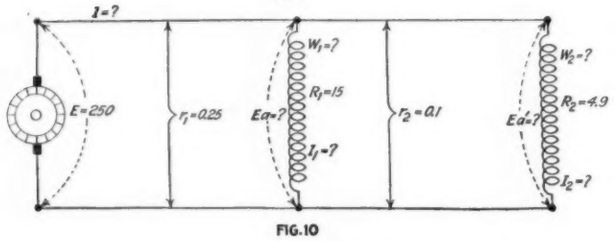


FIG. 10

FIGS. 9 AND 10. COMPLEX CIRCUITS

= 233.125. The resistance R_1 of the circuit between the two loads is that of 550 ft. of No. 0 conductor, or $R_1 = \frac{10.7L}{cir.mils} = \frac{10.7 \times 550}{105{,}500} = 0.056$ ohm. Volts drop in this part of the circuit is $E'_d = R_1 I_2 = 0.056 \times 125 = 7$ volts, and the available voltage at the load is $E'_a = E_a - E'_d = 233.125 - 7 = 226.125$. The watts loss in the first section of the circuit is $W'_l = E_d I = 6.875 \times 275 = 1890.625$. In the second section the watts loss in the line is $W''_l = E'_d I_2 = 7 \times 125 = 875$, and the total watts loss $W_l = W'_l + W''_l = 1890.625 + 875 = 2765.625$. The watts supplied to the first load is $W'_a = E_a I_1 = 233.125 \times 150 = 34{,}968.750$, watts supplied to the second load is $W''_a = E'_a I_2 = 226.125 \times 125 = 28{,}265.625$, and the total watts supplied to the two loads is $W_a = W'_a + W''_a = 34{,}968.750 + 28{,}265.625 = 63{,}234.375$. The total watts supplied to the system is $W = W_l + W_a = 2765.625 + 63{,}234.375 = 66{,}000$. The total watts is also $W = EI = 240 \times 275 = 66{,}000$, which checks up with the foregoing value.

In Fig. 10, r_1 and r_2 refer to the resistance of the two line wires the arrows point to. In addition to finding the values indicated by the interrogation marks, find the total watts, kilowatts and electrical horsepower supplied to the system.

Taylor Condensation Meter

The desirable feature of a meter is accuracy and dependability for long periods of service. A meter that seems to possess these with other desirable characteristics has been designed by the Taylor Underground Heating System, Pittsburgh, Penn.

This meter (Fig. 3) contains, within a metal case, four copper and brass buckets (Fig. 1) attached to an anti-rust shaft which revolves in an anti-friction self-lubricating bearing. The turning movement of the buckets and the shaft is so sensitive that the addition of one-quarter ounce of water will move the full bucket when it is ready to dump. The buckets are held in the filling position by a locking device in the dial box of the meter until the proper amount of water has been delivered to the bucket being filled. Then the full bucket moves to the dumping position; the next bucket cuts in when the full bucket moves $\frac{3}{16}$ inch.

The locking device is shown in Fig. 2. Each bucket is provided with a cam, the surface of which gradually increases in radius in the direction of the rotation of the buckets and terminates at its highest end in a stop projection *A*, the outer edge of which projects beyond the peripheral surface of the cam portion. A camwheel *B* revolves on a pin in the arm *C* and runs on the surface of the camwheel. This arm is fulcrumed at *D*, and the other end of the arm engages, by means of a slot, with the pin *E*, which is carried by the cylinder *F*, which telescopes over a plunger *G* pivoted to the metal case.

The dashpot plunger is made with an air-inlet port *I*, which is controlled by a check valve *J*. An escapement port *K* is provided, the lower portion of which is designed to be moved into and out of register with the opening *L*.

The operation is as follows: Water of condensation enters the meter at one end of the storage chamber, where it strikes a baffle plate. From the storage chamber the liquid flows through an opening (Fig. 1) and is deflected by the curved bottom of the vertical bucket into the bucket to be filled, which is held in its filling position by the engagement of the roller *B* (Fig. 2) with the stop *A*. When the bucket becomes filled with a predetermined weight of liquid, which is regulated by the

adjustment of the weight *O*, the resistance of the roller against the stop is overcome and the shaft and the bucket will revolve one-quarter turn, until the next bucket is in the filling position and the full bucket is discharging. It is evident that as soon as the full bucket begins to rotate, the following one ceases to divert the liquid into it, and the empty bucket will be brought into position to receive the discharge from the receiving chamber.

After the roller passes over this stop to the position shown at the right of Fig. 2, the shaft revolves through 90 deg. to bring the next bucket into the filling position. In this position the dashpot cylinder has been pulled upward so that the ports *K* and *L* are out of register. During the next 90-deg. movement of the shaft the cylinder will be moved downward as the roller rides up on the cam. When the roller reaches the position shown at the left of Fig. 2, the arm has moved downward until the slot in the end engages the pin *E*, when the cylinder *F* is forced dowr a short distance, quickly compressing the air until the roller is brought to a rest by engaging one of the stops.

The purpose of the dashpot is to act as a controlling device so that the meter will not trip until the predetermined weight of liquid has been collected in each bucket. It also guards against possible spinning of the bucket shaft after it has been released and insures the stopping of the next bucket at the correct filling position. The air that is trapped in the dashpot cylinder acts as a brake upon the camwheel until such time as the cylinder moves to a position to bring the ports *K* and *L* into register.

As the buckets and shaft make a complete revolution, there is no possibility of the shaft wearing flat, and the turning movement also eliminates the deposits of sediment in the bucket.

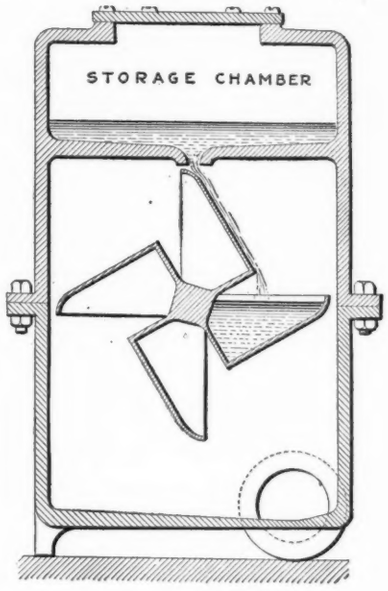
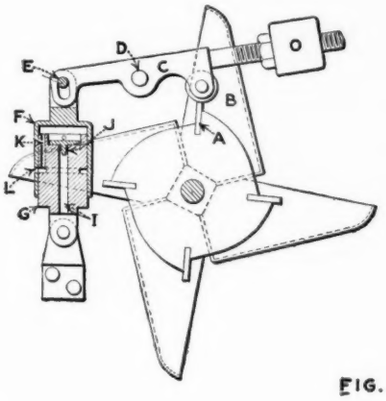


FIG. 1



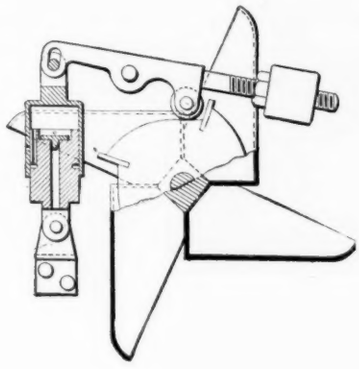


FIG. 2

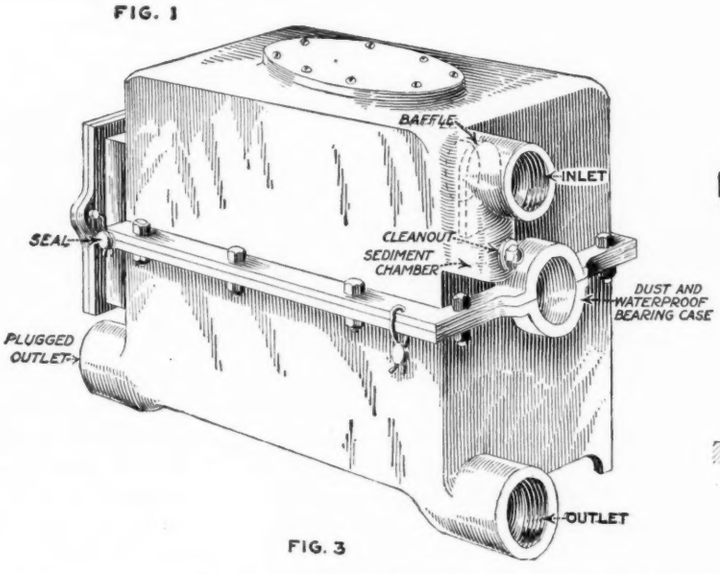


FIG. 3

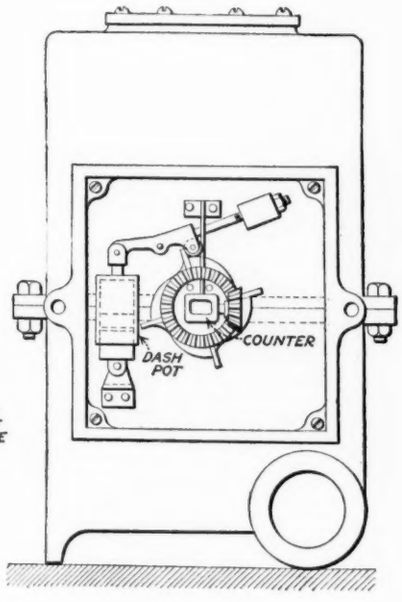


FIG. 4

FIGS. 1 TO 4. DETAILS OF THE TAYLOR CONDENSATION METER

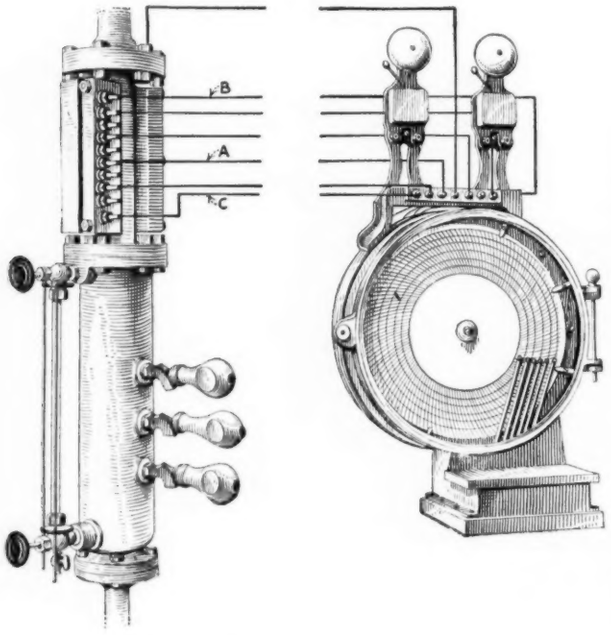
Fig. 1—Position of buckets when filling. Fig. 2—Details of locking device. Fig. 3—Meter box and connections. Fig. 4—Meter counting mechanism

All outlets are in the base of the meter, and therefore water will not remain in the bottom when the meter is not in operation. The count mechanism, Fig. 4, is inclosed in a damp- and dust-proof dial box to prevent corrosion. The meter reads direct; that is, if the dial shows 5000 it means that 5000 lb. of water has passed through the meter.

The meter is made in capacities from 400 lb. of liquid per hour to 200,000 lb. and is guaranteed to measure accurately to within one-half of one per cent.

Wight Electrical Boiler-Level Recorder

It is common to hear either the high- or the low-water alarm sounding in boiler plants. Water should not be allowed to drop too low because of the danger of burning the boiler, and when the water is carried too high there is the danger of priming and of slugs



ELECTRIC WATER-LEVEL RECORDER

of water going over into the engine cylinder. Then there is the economic advantage in keeping the water level constant in that the feed water is put into the boiler only as fast as it is evaporated. Such regularity in pumping feed water also allows the maximum amount of heat transfer from the exhaust steam to the feed water in passing through the heater.

An instrument that has been designed to record the water level in a boiler, making a continuous record of extreme low, high and all intermediate levels, is manufactured by the Wight Electric Recorder Co., Cleveland, Ohio. This instrument consists of multi-recording pen arms and is equipped with both high- and low-level alarms. On the top of the water column is a contact chamber in which contact is made at the various terminals as the water level in the boiler changes. The contact mechanism is actuated by a noncollapsible float which is filled with gas, at approximately boiler pressure, which increases and decreases as the pressure on the outside of the float fluctuates.

The operation of the recorder is about as follows: Assume that the water level is at the middle gage of the water column, the float contact will make connection with the contact *A*, which is connected to a corresponding pen arm of the recorder. At extreme high-water contact is made with the connection *B* and with connection *C* at the low-water level; likewise with the remaining connections as the water may vary up or down. By this instrument a record of the water level carried during the 24-hour period covered by each chart is shown and at what time it was at any particular level.

The recording dial can be placed at any convenient point about the establishment, and the instrument can be used for a number of purposes, such as recording the trips of an elevator, skip hoist, mine skip or any other machine where a record of what it is doing is required.

Motor Sparked When Starting

BY E. C. PARHAM

An armature coil that is short-circuited, as, for example, by two of the commutator bars being metallically bridged, will soon be burned out, because the voltage of the coil when in an active part of the field is considerable, while the resistance of the short-circuit is almost negligible. An armature coil that is open-circuited as, for example, by a broken or burned-off lead, will cause a spark to travel around with the commutator, the spark being maintained across the bars that include the open-circuit. Short-circuited coils are of comparatively frequent occurrence and so are open-circuited coils, but probably it is rarely that both conditions occur in the same coil, as they did in the following instance:

In regard to a 15-hp. 500-volt direct-current motor which was sparking, an inspector was informed that for more than a year the motor had been acting just as it was then. The commutator would show a traveling spark when the motor was being started, but as soon as the armature reached about half-speed, the sparking would cease. Inspection disclosed that one coil of the armature was entirely burned out as far as the course of the coil could be followed. Since the machine was taking only about one-third full-load current, and it was apparent that the motor would continue to run for some time as it had been running, and as it was essential that the machine be kept in operation, a new armature was ordered and the old one kept in service in the meantime.

When the new armature was installed, it was found that in the old one the ends of the affected coil were connected to adjacent commutator bars, the leads of which in some way became crossed, first short-circuiting the coil, then open-circuiting it. The open-circuit occurred in such a way that the two stubs that led to the commutator were apart as long as the armature remained at rest or did not exceed a certain speed. Above this speed, however, the stubs were forced against each other by centrifugal force, thereby bridging the bars that included the break and thus eliminating the traveling spark. A loose connection in the commutator frequently produces the foregoing effect.

Editorials

A National Engineers' License Law

A FEDERAL law providing for the examination and licensing of power-plant engineers in the same way that marine engineers are examined and licensed by the United States Board of Supervising Inspectors of Steam Vessels has been regarded as an impossibility under our Constitution upon the ground that it would be an unwarranted interference by the central Government with the internal affairs of the forty-odd sovereignties of which the Union is composed. So long as the preservation of the public safety was the only ground for such legislation, this contention was unanswerable, and it has been generally conceded that, in spite of the desirability of nation-wide and uniform requirements and practice, any regulation of this kind must be undertaken by the individual states.

But in these days when a common danger has emphasized the significance of common interests and the importance of general, over-all, inclusive efficiency, it is becoming apparent that there is a broader ground for inquiring into the operation of power plants in the communal interest. The immediately apparent motive for legislation against the use of unsafe boilers or the unsafe use of any boiler is the avoidance of killing and maiming people and destroying property in the immediate neighborhood. But the effect of a boiler explosion reaches much farther than this. In its reduction of man power, its interruption of production, its destruction of the fruits of labor, its addition to the burden of the community in caring for the injured and their dependents, it adds indirectly and in devious ways to the common cost of living. It is a defeat, a setback in the eternal conflict of man against the forces of nature; an impairment of his fighting force, a disaster with much more than a local significance.

The loss to the community, to the nation, from an occasional boiler explosion, considerable and desirable of prevention as it is, is insignificant as compared with the avoidable waste that is continually going on. Every ton of coal wastefully burned is an unnecessary impairment of the national resources and makes every other ton of coal and every unit of the product which it is burned to manufacture cost more.

The coal burned in the power plant of a shoe factory is an item in the cost of the product. If the product is sold at cost plus a fair profit, every purchaser of shoes has a monetary interest in the efficiency of the shoe manufacturer's power plant. In a time like this, when a shortage in the national coal bin is of such far-reaching, obvious and vital importance, the right of the nation to insist upon the economical use of fuel is practically unquestioned. Sixty-seven per cent. of the coal mined in this country is shoveled under boilers by about a quarter of a million firemen. It is claimed by those who have made a specialty of the subject that twenty-five per cent. of this could be saved by the exercise of a reasonable amount of care and an easily attainable amount of skill on the part of this quarter of a million men. Is it not conceivable that the people of the country in their collective capacity—that is, through the Federal Government—may insist that the steam plants of the country be operated efficiently as well as safely; and inasmuch as the effects involved are not confined by political boundaries but are nation-wide, that the supervision necessary to bring this about is a legitimate function of the Federal Government?

Save Coal in the Home

OF THE six hundred million tons of coal produced last year in this country, twenty per cent. was used for domestic purposes, and about fifteen million people shoveled this coal into their respective furnaces or stoves. The ordinary scoop shovel will hold about ten pounds of coal. At the prevailing market prices the small consumer had to pay five cents per shovelful for anthracite and for the same sum obtained double this amount of bituminous coal.

Such a small saving as one shovelful per day by each user would amount to seventy-five thousand tons, which for six months of the heating season, one hundred eighty days, increases to thirteen and one-half million tons.

The saving by each consumer is infinitesimal when compared to the total coal mined, but the aggregate saving is large. It is entirely possible to effect. More careful firing methods and overhauling of the furnaces to put them in first-class condition would do it. This particular case is only one of the many illustrations of what may be done when efficiency is the keynote and waste a crime. Under the circumstances it is the duty of every householder to reduce his coal requirements. One shovelful per day will work no hardship. It is a service that Uncle Sam will appreciate.

A New Principle in the Flow of Heat

IN AN article entitled "A New Method of Increasing the Evaporation in Boilers," on page 10, Dr. Carl Hering describes what might really be called a new principle in the flow of heat. The value of the legs of a pot as heating surface is one of the perennial subjects of discussion, and the use of knobs, projections and fins for increasing the absorption and radiation of heat is common, but Dr. Hering shows for the first time, to our knowledge, the underlying principle upon which such extensions should apparently be based, and by which their effectiveness may be greatly increased. When a flame plays against a relatively much cooler body, as that of an alcohol lamp against a beaker of water, there is formed a film of extinguished gas between the flame and the beaker, which cannot get away before it gets so cool that it will not char paper. The common

experiment of sticking a postage stamp to the bottom of a tin dipper and boiling water in it without charring the stamp is a demonstration of this fact.

The author of the article in question found that the resistance of this film to the passage of heat diminishes rapidly with the difference in temperature between its confining surfaces; that is, between the hot surface of the beaker on one side of this film and the flame on the other side of it. The temperature of the flame is fixed, but that of the receiving surface can be increased by interposing a certain amount of thermal resistance between it and the relatively cool fluid. This, in effect, is what he says the "pot legs" should be made to do, and when they are proportioned in accordance with the principle described and the values obtained by Dr. Hering, they seem to add in a remarkable degree to the activity of the heat transfer. He maintains that his researches also show the older idea of increased surface to be false and misleading, which, if true, would show why others had been groping in the dark with but small gains.

Lightless Nights and Nonessentials

THE original Fuel Administration order on the dimming of electric signs, which was intended to restrict the use of fuel-consuming signs to the period between 7:45 a.m. and 11 p.m., has failed in producing the coal-saving results that were expected. There may be two reasons for this—that the users of the electric signs deliberately ignored the order regarding their use or that they continued to use them with the belief that no one else would obey the order and that the coal situation was not so serious as has been claimed.

It would seem that anyone at all interested in the fuel question would have come to the conclusion long before this that there is a fuel shortage, regardless of whether it is the fault of the mine producers or that of transportation. With factories shutting down in Pittsburgh, Cleveland and other cities because of a lack of coal sufficient to generate steam for power purposes, the fact of a coal shortage is being brought home in a manner that cannot be gainsaid, and coal users are beginning to realize that the coal question is a serious one throughout the country.

As a result of the noncompliance with the original order of the Fuel Administration, a new order has been issued and was put into effect on Sunday night, December sixteenth, when Broadway and other "white ways" throughout the country were made lightless. Under the new order two nights each week will be lightless nights, and these are designated as Sunday and Thursday. Under the new order the "white ways" of our cities are to disappear absolutely on the nights designated. The burning of lights contrary to the wording and spirit of the order will constitute a violation of the law, and steps will be taken by the Fuel Administration to mete out punishment to offenders.

The coal shortage has caused considerable unrest among the manufacturers of nonessentials, and perhaps the first city to bear the burden of the power shortage is Pittsburgh, under an order issued by Robert J. Bulkley on the authority of the Priorities Board.

Mr. Bulkley investigated the industries of Pittsburgh using electric power, and the new order as arranged will go into effect as soon as it is possible to get instructions from Washington designating the concerns that are making nonessentials, a list of which has already been compiled. The procedure, it is understood, will be merely to forward this list to the power companies and depend upon them to cut out electricity from these concerns, but the list may be revised from time to time. Munition plants will be given every privilege, and no further curtailment of their operation will be permitted.

To just what extent this measure of conserving coal for the necessary industries engaged in munition work will operate, cannot be foretold, and it is doubtful if the Government will favor arbitrary limitation of any industries except as a last resort, in the event of an acute shortage of coal. It stands to reason that when for any reason the coal situation in the country gets to a point where war interests are threatened with closing down, the nonessential producer will be obliged to suspend operations.

Business Editors at Washington

THE business press of the country talks to a large constituency in the language that its readers best understand and from the vantage point of an exponent of their interests. The esteem in which it is held by those in authority is evidenced by the fact that such people as F. W. Taussig, Chairman U. S. Tariff Board; Eliot Wadsworth, Vice Chairman American Red Cross; J. D. A. Morrow, Secretary National Coal Association; Harry A. Garfield, Fuel Administrator; Food Administrator M. L. Requa; Frederic A. Delano, Member Federal Reserve Board; Senator Francis G. Newlands, Chairman Joint Congressional Committee on Interstate Commerce; E. N. Hurley, Chairman of Shipping Board; Senator Atlee Pomerene, Member of Committees on Banking and Currency, Foreign Relations, and Manufactures; Dan C. Roper, Commissioner in Charge of Collection of Excess Profits; A. W. Shaw, Chairman Commercial Economy Committee, Council of National Defense; Dr. Anna Howard Shaw, Chairman Woman's Committee, Council of National Defense; and C. A. Richards, Chief Bureau of Exports, agreed to meet a delegation of some seventy-five editors of American business papers and give them in short addresses the high points in the work which they are doing. J. D. A. Morrow, Secretary of the National Coal Association, appeared in the place left vacant upon the program by the failure of Secretary Lane to appear, and M. L. Requa represented Mr. Hoover, who was unable to be present. Dr. Garfield's remarks on the coal situation will be found in another column.

President Wilson's taking over of the railroads will be generally approved. The transportation system of the country should be an entity operated at maximum efficiency, not as measured by the ratio of dividends to investment but by the ratio of service to cost. It may be that somebody's remark about unscrambling eggs may come home to roost.

The index to Volume 46 (the last six months of 1917) will be ready shortly and will be sent to all whose names are on the index mailing list. Any others who wish will be put on the list. A post-card request is sufficient.

Correspondence

High Speed of Steam Turbines

In connection with the question of steam-turbine failures, which is discussed in recent issues of *Power*, a statement of our practice and experience might be of interest to your readers.

The safe speed for our standard noncondensing wheel is so far in excess of the usual operating speed that we do not as a regular practice find it necessary to run any special overspeed test unless the turbine is to operate regularly at an unusually high velocity. The regular overspeed run which we make for the Government is 25 per cent. over the normal rating. The maximum test speed at which we can operate our different rotors is so far above this value, however, that we seldom approach it. These maximum test speeds vary from 4000 to 7000 r.p.m., depending on the diameter of the wheel.

When it is considered that for condenser-auxiliary drive, boiler-feed or boiler-draft service operating speeds for direct-connected units seldom exceed 2500 r.p.m. and for 60-cycle alternator speeds, 3600 r.p.m., such high-test speeds allow a wide margin of safety.

It is possible to injure any wheel by sufficiently overspeeding it, and it is highly important that the design of a wheel be such that if it is accidentally run to this speed as little damage as possible will result. To insure maximum strength, the Terry rotor is cut from solid steel, even the buckets being milled from the solid steel. The semicircular notch in the center of the bucket incidental to manufacturing proves a further source of strength and safety, due to a reduction in blade weight and stresses. When the speed is approaching the danger point, the corners of the bucket next to the semicircular slot begin to bend upward. These will strike on the edges of the reversing chambers and will usually give warning before anything very serious occurs. The web is made much stronger than the blades, so that should the turbine overspeed for any reason whatsoever, the individual blades would shear out, resulting in decreased speed before reaching the danger point for the web. The blades are very light, therefore the worst they can do is to injure the nozzles and reversing chambers. We have actually run machines to destruction for experimental purposes, and found that when this occurs no part of the turbine rotor will come through the casing. Although we have more than 4000 turbines running, we know of only one case in which anyone has been injured by a wheel bursting and that by a type we no longer build.

Some time ago, while making tests on our multi-stage condensing machines, we took a wheel which was then standard and ran it to destruction. The blades were one-third longer than any blade of equal shape we are now using. The wheel disk, was, however, of the same type as now used. At approximately 5200 r.p.m. the buckets came out of their fastening. Since that time improvements in the strength of our blade fastening have made it three times as strong as at the time of the test. We are using no blades as heavy as the ones that were in the first wheel and are limiting the speeds on this particular diameter of wheel to 4000 r.p.m. in the multi-stage machine. As constructed now, these wheels will safely stand a test speed of approximately 6000 revolutions per minute.

In addition to having a high factor of safety for the wheel, in the standard noncondensing turbine there are no close side clearances to be maintained and there can be no fouling of the blades due to a slight axial wear or misadjustment. Even if the bearings wear down, the moving blades cannot strike on the stationary blades, as they are protected by a substantial rim that projects beyond the blade. The only thing that can strip the blades is serious overspeeding or the presence of some foreign substance.

J. BRESLAV., Sales Eng.,
Terry Steam Turbine Co.
Hartford, Conn.

Suggested Designs for Centrifugal Machinery

I was interested in reading C. E. Pratt's letter on "Suggested Designs for Centrifugal Machinery" and his comments on the steam motor in the Nov. 20 issue of *Power*, page 704.

Mr. Pratt suggests going a step farther with the design than suggested by the Steam Motors Co., by doing away with the bedplate and having the pump and turbine bolted together by vertical flanges. This design is quite feasible and has been already adopted by one or two manufacturers. But when we attempt to make a rabbeted fit at this point, it must be borne in mind that this is not so easy as it looks for the reason that these two flanges will be machined in separate shops, which is a different proposition to machining both flanges to one set of gages.

Again, this arrangement necessitates a special pump, whereas with the design suggested in the steam motor a standard pump is used without any change in existing patterns.

I do not quite understand Mr. Pratt's reference to a third bearing, in the second paragraph of his letter. He asks: "Why not do away with the third bearing, leaving in this instance the prime mover entirely overhung?" This is exactly the way the steam motor is designed, and there are only two bearings in the steam motor combination, as he will note if he looks over the original article.

Regarding the question raised by Mr. Pratt as to why more manufacturers do not build both ends of the unit, the answer is that this is an age of specialization and a concern which devotes all its energies to manufacturing one particular line of apparatus is in a better position to perfect that than if it built several different lines. Mr. Pratt goes on to say that this

would, in most cases, solve the problem of assembling two machines, in addition to having only two bearings for the complete unit. As already mentioned, this is what we have with the design of the steam motor. We do not assemble two machines together in the true sense of the word, as the steam motor automatically becomes part of the equipment to which it is attached and has the advantage, which Mr. Pratt feels is very important, of having only two bearings for the complete outfit.

I am entirely in sympathy with Mr. Pratt's ideas regarding standardization, and he will find a paper devoted in a great measure to this subject, presented before the American Society of Mechanical Engineers at its annual meeting in December, 1917. [This paper will soon appear in *Power*.—Editor.]

W. J. A. LONDON, Engineer,
Springfield, Mass. The Steam Motors Co.

American Blowing Engine in Italy

One of the remarkable events taking place in Italy today is the supplanting of German machinery by American products. The war is teaching Italy that an exchange of her surplus products for American goods is preferable to the pre-war dumping system.

Throughout the country one meets American engineers assembling or erecting American machinery. In Turin over one hundred Baldwin locomotives have been delivered recently, and in Brindisi more locomotives are being assembled, and the chain is complete from the Alps to the southern Adriatic. An American engineer, Henry Louis Hammerle, is erecting for the Mesta Machine Co., of Pittsburgh, a monster blowing engine at the Ilva steel works in Bagnoli, near Naples. This blower, the largest in Italy, is designed to deliver 37,100 cu.ft. of air per min. to the blast furnaces where Elba Island iron ore is reduced. The bedplate alone weighs 160,000 lb. and is larger than any other casting ever imported into or manufactured in Italy. It was with

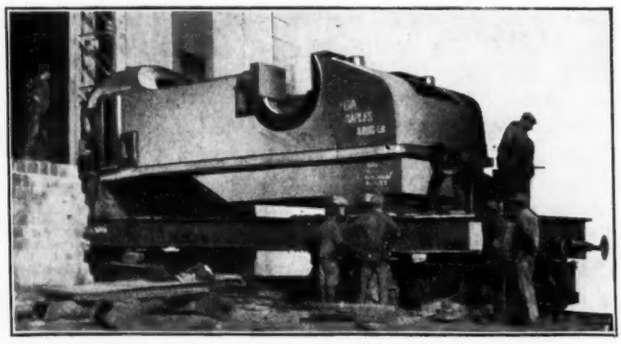
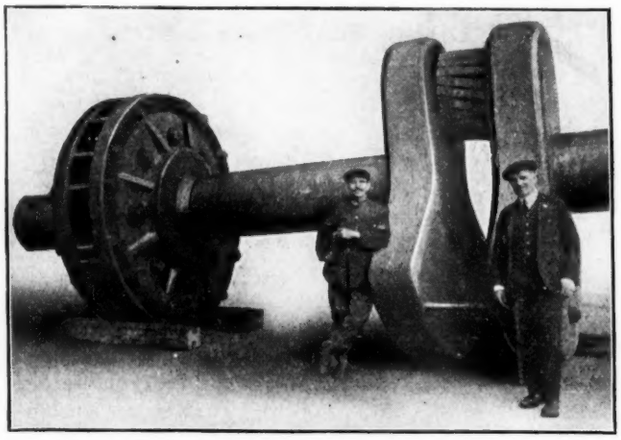


FIG. 1. UNLOADING THE ENGINE BEDPLATE AT THE PLANT

much difficulty that the engine was stowed for shipment aboard a tramp steamer, and it was then buried under a load of coal. Its total weight, including the flywheel, is 1,200,000 lb. The flywheel is 24 ft. in diameter and weighs 160,000 lb. The cylinder is 46 in. diameter and 60-in. stroke.

The Italian buyers are pleased with the complete oiling system of the engine, since it saves 75 per cent. of the oil, a matter of great importance in Italy. The foundations beneath their other engines are saturated with wasted oil. Italy produces no lubricating oil or coal, and very little iron, and Italian manufacturers are forced to look to other countries for these materials. Nearly all the oil and steel now come from the United States. One firm has used 300,000 tons of American steel since the war began, and another, a munitions



CRANKSHAFT AND HUB OF FLYWHEEL

plant, is using 2400 tons a month. About two- thirds of Italy's coal comes from England and the remainder from America. The present price of coal is one thousand lira ($130) per ton. American products find a welcome in Italy even under the present almost prohibitive freight rates.

The illustrations show the bedplate and crankshaft of the blowing engine referred to in the foregoing.

Paris, France. A. R. DECKER.

The Engineer and the Union

Referring to the letters that have recently appeared concerning the engineer and the union, I think the unions are good enough in their way, but are lacking in one important respect; namely, almost anyone can call himself an engineer and join the union. The unions should have an examination as strict as that of the license examiners, so that the employer can have no justification in objecting to the higher wages demanded, considering both the safety of his plant and his pocketbook. So many employers have been stung that one can hardly blame them for their objection to employing uncertified men.

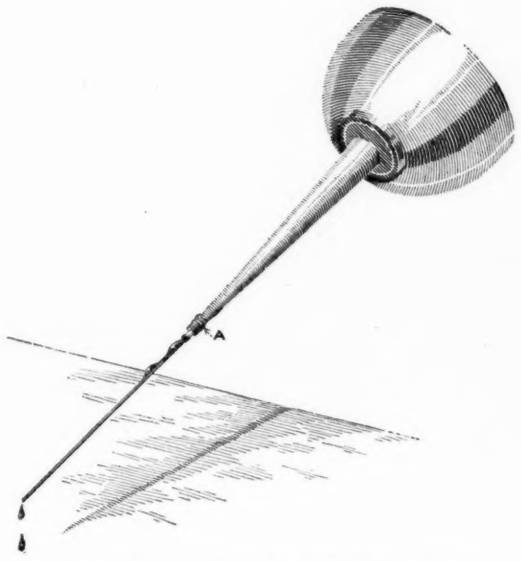
But another unfortunate side of the question is, that with the present scale of wages there is not much encouragement for a young man to keep plugging for a higher position with the responsibilities and cares of the chief engineer. We can't all be bosses, so all we can do is to train for the position and be ready when the opportunity arrives. In the meantime we should have a wage sufficient to maintain ourselves, with a few of the good things of life on the side.

These are views I have heard expressed by engineers in different parts of the country. Something should be done, and the greater the publicity the subject can be given the better. I would like to see conditions changed, but it will probably take a long time.

Emmett, Idaho. GEORGE R. DYE.

Extension Oil-Can Spout

In the issue of Oct. 30, page 603, Mr. Forray shows an extension for an oil can for oiling parts above reach without climbing a ladder. A convenient way to oil parts below reach when no long-spout oil can is at hand



WIRE EXTENSION ON OIL-CAN SPOUT

is by attaching a stiff iron or copper wire to the spout of an ordinary oil can as shown in the illustration. As the oil comes out of the spout it will follow the wire to the point intended. D. R. HIBBS.

New York City.

Bad Packing Conditions Overcome

I experienced a lot of difficulty trying to hold the piston-rod packing in an engine under my charge. I cast two rings of babbitt to fit the rod closely and go into the stuffing-box. One of these was put in the bottom or back end of the stuffing-box, then soft packing and last the second ring of babbitt.

With the gland tightened up only moderately, the packing does not leak and the engine runs splendidly.

Altman, W. Va. JOHN FRENCH.

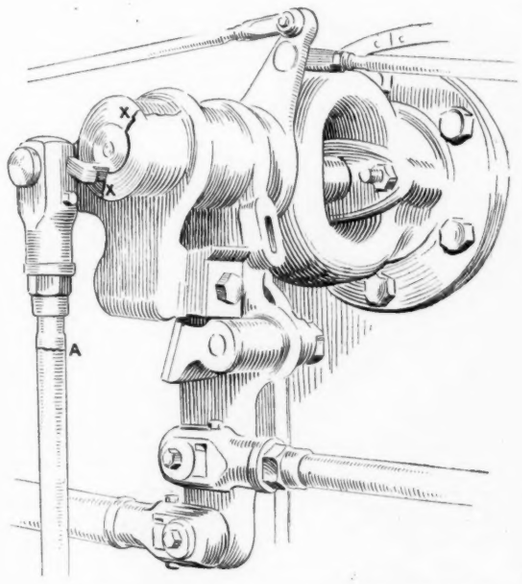
Valve Gear Broken by "Blocked" Valve

One unit of a large power plant is a 700-hp. simple Corliss engine. One noon hour, after most of the plant crew had finished lunch and were sprawled around the engine room waiting for the starting whistle, a blood-curdling racket, described as a cross between a cat serenade and a hog-killing squeal, started in a corner of the room. The lights danced and the brushes on the generator flashed and squealed; so the men "scooted" out by the shortest route through doors and windows and, after reaching what they considered a safe distance, turned to see if the whole power house was following.

The chief, one assistant and one oiler were the only ones who stood their ground, though in truth they were all shaky in the knees, and they began a cautious investigation to determine where the unearthly sounds originated. They seemed to come from the corner where the feed-water heater was located, and while they were gathered around the heater for a moment there was a howl at the commutator of the large engine unit running in parallel with two smaller ones, followed by several flashes, and the circuit-breaker "kicked" out. The chief shut off the throttle and noticed that the dashpot rod was broken at *A*, as shown in the illustration, and that the steam arm was gone—had dropped into the oil pan under the valve gear so that the bare valve stem was staring him in the face.

The steam arm had been broken across the hub, as indicated by *X* in the sketch. In attempting to turn the valve closed, it was found impossible to do so, but it moved freely in the reverse direction, and when the bonnet and valve were removed it was found that a piece of the threaded end of a pipe had dropped into the steam chest and worked into the port when the valve opened, and prevented it from closing, and of course something had to let go; in this case it was the steam arm.

The explanation of the noise was then simple, for the steam valve being wide open, every time the exhaust valve opened, the steam at full boiler pressure rushed into the exhaust line that ran under the floor as far as the heater, where a tee connected it with the vertical riser to the back-pressure valve. Evidently, considerable water had accumulated in this tee during the light load period at the lunch hour, so that when the live steam rushed through, it caused the terrific



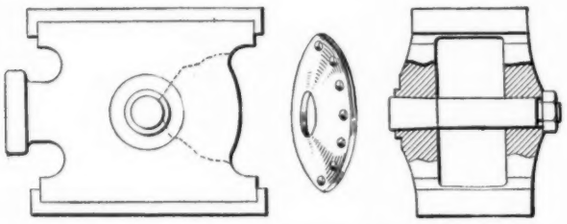
STEAM ARM AND DASHPOT ROD BROKEN

racket and the engine could work only on one end, so the governor was unable to control the speed and voltage and the circuit-breaker went out with the usual fireworks. A new dashpot rod was made and the broken steam arm was oxyacetylene welded and rebored, after which it served the purpose as well as ever. The repairs were made and the engine was ready to run in three hours after the accident. E. W. MILLER.

Minneapolis, Minn.

Repairing a Broken Crosshead

The wristpin of a Corliss engine (18 x 42) was worn, so we placed the crosshead in a wheel press to remove the pin, as it had been pressed in, but in doing so the crosshead was cracked as shown by the dotted lines in the illustration. The crosshead was clamped firmly, chucked in the lathe and the side turned off, leaving a half-inch boss, or shoulder, around the eye. Then a



FLANGE SHRUNK ON A BROKEN CROSSHEAD

piece of ½-in. boiler plate was shaped, as shown, with the hole in the center a little smaller than the boss on the crosshead. After being heated in a forge, it was placed on the crosshead and hammered to a good fit. When cold, it had drawn the parts together so closely that the cracks could hardly be noticed. Holes were then drilled around the patch and tapped out for cap-screws, making the job entirely secure.

Braemar, Tenn. J. W. STANLEY.

Change of Water Supply for Air Pump

In answer to L. F. Forseille's request, page 703 of *Power*, Nov. 20, relative to changing injection piping to air pump, I offer the following: I take it that the increase of 75 deg. F. of the injection water referred to by Mr. Forseille is the range between the cold water of winter and the warmer water of the summer months.

In designing the air-pump runner the builder would figure on capacity with the warmest water it was to handle in operation, which would be in the summer, and as a drop in temperature in the colder seasons would increase the air-runner capacity, the manufacturer would not worry about that. When the air runner is handling water of a given temperature, it discharges it with a certain velocity, assuming the runner to have a fixed peripheral speed.

At this temperature, volume, weight and velocity the slugs of water exert a certain velocity head, which is transformed into pressure head in the diffusion nozzle upon leaving the runner and so overcomes the discharge head the runner works against.

Now, if we consider that the air runner is designed to discharge a certain amount of air in the summer months with water at 80 deg. F., and we increase the temperature to 110 or 115 deg., as the suggested increase would do, we necessarily increase the volume of the water for a given weight, and this lighter water by volume limits the ability of the runner to store enough kinetic energy in the slugs of water to overcome the forces acting against the water.

In concluding I would suggest increasing the pump speed, as a small increase in speed will probably secure the desired results. R. B. GOOLD.

Leadville, Colo.

Water Too Hot for Feed Pump

At one time it was my good fortune to act as watch engineer in a small modern central station situated on one of the Great Lakes. There were four vertical water-tube boilers of 5000 sq.ft. of heating surface each, often worked to 300 per cent. rating. The engine room contained two 1000- and one 2500-kw. turbo-generators, exhausting into jet condensers when desired, but in winter the exhaust was used to supply a district heating system. There was one motor-driven three-stage centrifugal boiler-feed pump, with a rated capacity of 200 gal. per min. and also a turbine-driven pump of the same size and capacity, but the turbine was unable to drive the pump fast enough even with the governor cut out of service, so it was little used. There was one other pump of the duplex type, used for general service, which could be used as a boiler feeder, but was of a light pattern and not suitable for such hard work.

One morning in midwinter when the mercury was at zero, I went on watch at 8 o'clock and found everything going at top capacity, but pretty soon things began to happen in rapid order in the boiler room—the feed pump failed to supply enough water, and it went out of sight in all four gage-glasses. You can imagine my feelings at finding this condition and all the pumps working. I recalled that the chief once remarked in a casual way that an engineer was expected to keep the plant running and not to see how quick he could shut it down.

Fortunately, I remembered in time that the delivery of a centrifugal pump falls off rapidly with a rise in temperature of its feed water, and finding that the water in the open heater was unusually hot, I lost no time in opening the bypass on the heater and sent cold water to the pumps. Then I went into the boiler room to watch results, which were not long in coming, for the water bobbed up in one glass after the other and the excitement was over. This was my first experience with a centrifugal boiler-feed pump, and I knew all the time that the capacity of a centrifugal pump changed with a change in temperature—but I didn't think, which is the trouble with a lot of us. R. B. GOOLD.

Leadville, Colo.

Climbing a Smoke-Stack

I saw three fellows climb a stack that had no ladder on it in a way that seemed to me far from safe. They passed a rope four times round the stack, then hooked three pullies on, at equal distances apart and each pulley on a different turn of the rope. Next, they pushed the ropes up the stack by means of long poles. When they had them up as far as they could reach, they were drawn up to the pulleys in "bos'n chairs" by other men on the ground. They then pushed another set of ropes up in the same way after making themselves secure to the first set. By repeating this process several times they reached the top of the stack.

Of course the coming-down part was easy as they were let down by the men below from a pulley on some kind of a grappling hook on the top of the stack like painters use on a house, and after they got down this was thrown off the stack. D. R. HIBBS.

New York City.

Inquiries of General Interest

Relative Properties of Copper, Iron and Zinc Wires—What are the relative properties of copper, iron and zinc wires for use as electrical conductors? M. L.

The relative electrical conductivities for equal cross-section are as 100 for copper, 17.4 for iron and 27.2 for zinc wire. The relative specific gravities are as 8.93 for copper, 7.86 for iron and 7.15 for zinc. The tensile strength per square inch of cross-section of copper wire is about 50,000 lb., of iron wire about 100,000 lb., and of zinc wire about 18,000 pounds.

Deflection of Water Tubes Away from Heat—What causes tubes of water-tube boilers to become bent away from the fire? J. A. S.

The most plausible reason given for deflection from the fire is that greater temperature attained by the fire side of the tube causes a greater expansion of length, and having elongation of the tube resisted by the headers, greater expansion on one side causes the tube to act like a strut or column that is eccentrically loaded, resulting in deflection of the tube away from the side that, from greater elongation, receives the greatest stress of longitudinal compression.

Cost of Leakage of Steam—What would be the daily loss from continuous leakage of steam at 100 lb. boiler pressure through an aperture of 0.1 of 1 square inch for 10 hours per day, where under actual conditions the evaporative economy of the boiler is 7 lb. of water generated into steam at 100 lb. gage pressure per pound of coal and the cost of coal $6 per ton of 2000 lb.? P. H.

Napier's approximate rule for the flow of steam into a pressure less than 58 per cent. of the initial absolute pressure is: Flow in pounds per second = absolute pressure × area of aperture in square inches ÷ 70. Accordingly, the discharge would be approximately (100 + 15) × 0.1 ÷ 70 = 0.1643 lb. of steam per second, and the loss would amount to

$$\frac{0.1643 \times 60 \times 60 \times 10}{7} \times \frac{\$6}{2000} = \$2.53 \text{ per day.}$$

Height of Settings of Return-Tubular Boilers—What are the advantages of high boiler settings over low settings for horizontal return-tubular boilers, and what considerations determine the limit of height? H. C.

With higher settings the gaseous products of cumbustion and volatile matter liberated from the fuel are not cooled so immediately after rising from the fuel bed by coming in contact with the boiler heating surfaces that are much lower in temperature. Consequently, there may be more perfect combustion of the gases attended by higher temperature. In addition to the extra cost of higher settings, considerations that limit the height of the boiler are that the higher the boiler the less heat will be received from the fire by direct radiation, and although the heat of the fire which is not directly absorbed by the boiler is beneficial in improvement of combustion and in increasing the temperature of the gaseous products of combustion, for the same amount and condition of boiler-heating surface there will be higher temperature and therefore more waste of heat in the chimney gases. Hence the height of boiler most beneficial to economy of fuel will depend on the dimension of the boiler, kind of fuel, force of draft and rate of firing.

Actual, Apparent and Equivalent Cutoff—What is the difference between actual, apparent and equivalent point of cutoff of a steam engine? F. N. C.

In the operation of the engine, the actual point of cutting off is the point that marks the fractional part of the stroke which has been completed at the instant when the admission valve in closing to cut off the supply of steam has just covered the port. The apparent point of cutoff may be the point that appears to be the actual point of cutoff from observation of the operation of the engine or from measurements and known relative adjustments of different parts of the valve gear; or the fraction of stroke that is assumed to be completed at the beginning of the expansion line on an indicator diagram. Equivalent point of cutoff is the earlier point in the stroke where actual cutoff would take place so as to cause the expansion line of an indicator diagram to pass through the point of beginning of the actual diagram, or practically coincide with the expansion line of the actual diagram, provided there had been no reduction of the initial pressure during admission, and cutoff had occurred instantaneously or, in other words, assuming theoretically perfect admission and cutoff.

Minimum Number Threads for Screwed Pipe Connections—What number of threads of a pipe or nipple should screw into a fitting or a threaded pipe connection of a boiler? G. M.

Screwed connections should have the minimum number of standard pipe threads required by the A. S. M. E. Boiler Code for threaded openings in boilers for 1-in. pipe or larger, as per the following table:

MINIMUM NUMBER OF PIPE THREADS FOR CONNECTIONS TO BOILERS

Size of pipe connection, In.	1 & 1¼	1½ & 2	2½ to 4 inclusive	4½ to 6 inclusive	7 & 8	9 & 10	12
Number of threads per in.	11½	11½	8	8	8	8	8
Minimum number of threads required in opening	4	5	7	8	10	12	13
Minimum thickness of material required to give above number of threads, in	0.348 = 11/32 +	0.435 = 7/16 —	0.875 = 7/8	1 = 1	1.25 = 1¼	1.5 = 1½	1.625 = 1⅝

If the thickness of the material of a boiler is not sufficient to give the designated number of standard pipe threads, there should be a pressed-steel flange or steel plate properly constructed and riveted to the boiler so as to give the required number of threads.

Lift of Valve To Obtain Full Opening—How much must the disk of a globe valve be raised off the seat to obtain full opening or the same cross-section of valve opening as the cross-sectional area of the diaphragm opening? J. D.

When the valve disk has a flat seat for covering a square-edged opening of the diaphragm, the area of the valve opening = circumference of the diaphragm × rise of the valve. Calling d = diameter of the diaphragm opening and l = lift of the valve, the cross-sectional area of the valve opening would be $\pi \times d \times l$. As the cross-sectional area of the diaphragm opening would be $\frac{1}{4} \pi d^2$, then for equality of areas, $\pi dl = \frac{1}{4} \pi d^2$, or $l = \frac{1}{4} d$; that is, for equal areas the lift must be equal to one-quarter of the diameter of diaphragm opening. When the valve seat is beveled to an angle of 45 deg., for equality of areas the lift of the valve must be about 36 per cent. of the diameter of diaphragm opening. It is not to be assumed, however, that equal projected areas in the different forms of valve seat will give the same coefficient of discharge, for that is influenced by the direction of flow of the gas, vapor or liquid in passing through the valve and also by the size, roughness and form of the shell or globe and the form and finish of the disk and its seat.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Recent Developments in Air-Pump Design*

By E. P. JONES

Reviews the chief progress in the design of air pumps from the Edwards reciprocating type to the newest multijector pump of Maurice Leblanc, which has many advantages over the well-known Leblanc hydraulic air pump. The paper is one of the most valuable yet presented on this auxiliary so important to turbine economy.

WITH the earliest types of surface-condensing equipment it was usual to employ one pump for removing both the condensate and air from the condenser. This pump was known as a "wet" air pump, and a good example of this type is the Edwards air pump, one of the most efficient of its class. The chief advantages of this type of pump are: (1) Low power required for driving; (2) positive action and consequent stability; (3) ability to cope with excessive air leakages. While the Edwards pump is still an excellent pump for units up to, say, from 3000 to 4000 kw., it must be remembered that, with the ever-growing size of power units, its disadvantages should be kept in view. For large units with Edwards pumps it is necessary that they should run at a very low speed, and consequently they are very cumbersome and take up a large amount of floor space.

With jet plants the Edwards pump is sometimes used as a dry air pump. It is necessary, of course, to provide a small quantity of water for sealing purposes. Volumetric efficiency in this pump varies considerably with the degree of vacuum required and decreases as the vacuum increases from about 50 per cent. at 3½ in. absolute pressure to 18 per cent. at 1 in. absolute pressure. Another system is that in which a dry air pump of the reciprocating type is used to remove the air and uncondensed gases and a separate pump to remove the condensate. The advantages and disadvantages of this system are the same as for the Edwards air pump, but the efficiency is rather better.

Previous to the introduction of the steam turbine condensing-plant equipments were furnished with air pumps of one or other of the types mentioned, but as soon as the turbine became a commercial proposition it was necessary to look for a type of pump having features specially adapted to its requirements. With turbine installations it is essential to use a high vacuum in the condenser, whereas with steam engines of the reciprocating type a vacuum of more than 26½ in. was seldom required. In fact, it is questionable whether using a vacuum higher than 26½ in. would not be considered a disadvantage. With the turbine, however, a vacuum less than 27 in. is rarely asked for, and sometimes the specified figure is as high as 29.25 in. with the standard barometer reading of 30 in. In considering these figures, due allowance must be made for the altitude of the place. The most economical vacuum for a turbine installation depends on a variety of things, and each case has to be considered on its merits.

On reference to steam tables it will be seen that an increase in vacuum from 27 in. to, say, 29 in., other conditions, as air leakage, remaining the same, necessitates an increase in the capacity of the air pumps from 1.00 to 3.25, which for a large installation with Edwards or reciprocating dry air pumps is a very serious matter. Therefore various types of rotary pumps, which are specially suitable for dealing with large volumes of air at low tension, have been designed since the adoption of the steam turbine, several of which have proved very successful. The general design of these pumps is much the same, in so far as they use a certain quantity of what is termed "operating water," for which various devices have been invented to cause this water to move in such a manner as to entrain the air from the condenser and discharge it to the atmosphere. Perhaps one of the best-known rotary dry air pumps is the one invented by Prof. Maurice Leblanc. It has been used to a large extent all over the world, and its action is shown by Fig. 1. This pump is capable of maintaining a very high vacuum, and for this reason, coupled with the fact that it

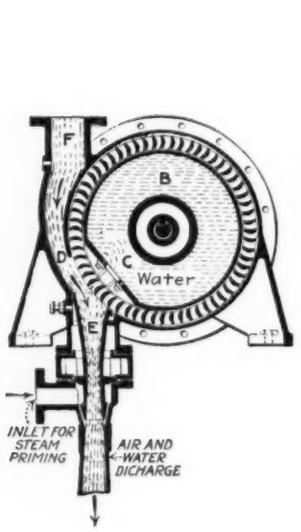


FIG 1

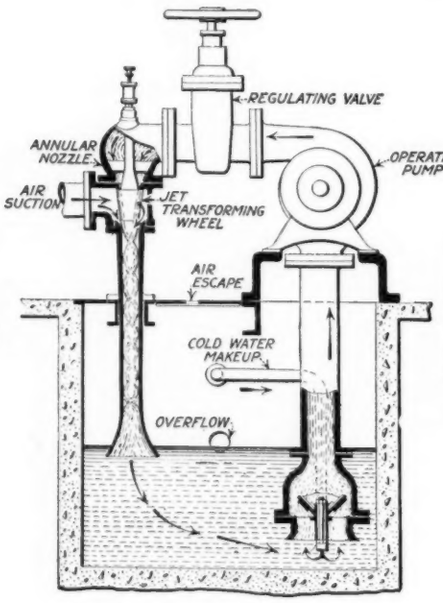


FIG. 2

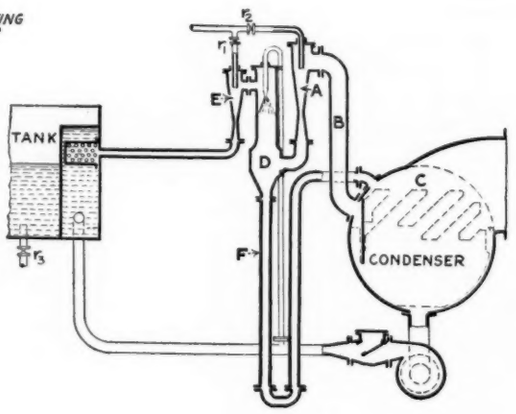


FIG 3

FIGS. 1 TO 3. TYPES OF AIR PUMPS AND THEIR CONNECTIONS
Fig. 1—The Leblanc air pump. Fig. 2—Worthington ejector air pump. Fig. 3—French type of ejectair air pump

*From a paper before the Institution of Engineers and Shipbuilders, Scotland, reported in "Engineering" (London), Sept. 7 and 14.

is very simple in construction and not likely to get out of order, it has been largely used for turbine installations. It cannot be claimed for this pump—or, indeed, for any type of rotary air pump—that it can successfully deal with an excessive air leakage, but consideration will show that this quality is not essential in the case of turbine installations where air leakage is reduced to a minimum by the adoption of steam- or water-sealed glands where the shaft passes out of the turbine casing. With a surface-condensing plant it is only possible for air to be brought into the system by the feed water and carried over with the steam, or by leaking in at the joints. With jet plants, the air brought in with the injection water has to be allowed for in addition to the above, and it is for this reason that the air pump on a jet plant requires to be larger than that for a surface-condensing plant doing the same steam duty.

The power required to drive these pumps is rather higher than that required for an Edwards or other good type of reciprocating air pump, and consequently a good deal of attention has been paid recently to another type of pump which would incorporate the simplicity and compactness of the rotary pump and the low-power consumption of the Edwards and other reciprocating pumps. The general trend of thought seems to have been in one direction, and there are now on the market and in commercial use air pumps operating on the ejector principle. Nearly all the leading condenser manufacturers now construct air pumps of this description.

The New Ejector Air Pump

The Worthington Pump Co., Ltd., London and Newark, manufacture a patent hydraulic vacuum pump on the ejector principle, as illustrated by Fig. 2, which consists of: (1) The injection head, (2) the air-suction chamber, (3) the rotary wheel, (4) the throat and tail pipes. The operating water passes between two nozzle rings, and the cone of water passes between the body of the wheel and the outer sleeve, impinging on the inclined surfaces of the vanes, thus imparting a rotary motion to the wheel. To operate the pump it is necessary to provide a certain amount of sealing water, which is supplied from a tank situated as conveniently as possible to the pump. The sealing water takes up a certain amount of heat from the air and water vapors withdrawn by the air pump, and a piping arrangement is provided for withdrawing a certain amount of this water by means of a bypass connection on the operating pump discharge, this bypass being fitted with a controlling reflux valve. The quantity of water withdrawn in this manner is replaced by makeup water drawn from the circulating inlet-piping or an independent supply, thus cooling the water used in the cycle of operation. This apparatus is doing regular service on one of the turbo-alternator groups at the Glasgow Corporation Power Station at St. Andrew's Cross. A number of installations have also been supplied to other concerns.

Willans & Robinson, of Rugby, manufacture the Willans-Muller ejector air pump, which is operated by the circulating water, either on the series or shunt system. With the series system the whole of the circulating water passes through the ejector before entering the condenser. With the shunt system only a portion of the cooling water passes through the ejector, and, after use, is returned to the pump suction or the source of supply. A third method of operating this ejector is by the separate-pump system, in exactly the same manner as described in referring to the Worthington pump. The whole plant is very similar to that made by the Worthington Pump Co. The Glasgow Corporation has a set of this apparatus at work at Pinkston Power Station, and good results have been obtained, and a second set is just being installed at St. Andrew's Cross.

Another type of ejector air pump is that manufactured by Hick, Hargreaves & Co., Ltd., Bolton, under license from the Mason Breguet, Paris. This is really two ejectors working in series, with an auxiliary condenser placed between the first and second stage of the ejectors. A number of these air pumps, termed "ejectairs," have been supplied to, or are under construction for, the French Navy. Referring to Fig. 3, it will be observed that the primary ejector *A* is placed in direct communication with the main condenser *C*, and extracts the aërated vapor, being operated by a single steam jet or nozzle r_2. The mixture of steam and partly compressed vapor is then discharged to the auxiliary condenser *D*, and the water returned to the main condenser to be dealt with by the extraction pump. The second-stage ejector *E* is coupled up to the auxiliary condenser, and draws the air away, discharging it to the feed tank. An automatic air-inlet valve is fitted to the auxiliary condenser, to regulate the absolute pressure therein. It is claimed that taking air from the atmosphere in this manner materially assists the stability of the plant, and also renders it more flexible. These *ejectairs* are designed for working with steam pressures at 55 lb. per sq.in. or above, and with a special arrangement of nozzles lower pressures can be used in the primary ejector, although the advantage of this is not apparent if it is impossible to work the other ejector under the same conditions, neither is it clear whether this can be accomplished or not.

The curves, Fig. 4, show the performance of an *ejectair*. Steam to the ejectors had an absolute pressure of 125 lb. per sq.in., and the steam consumption is given as 194 lb. per hour, of which 129 lb. is recoverable. The apparatus worked in conjunction with a small jet condenser, dealing with 94 gal. of injection water per minute. Curve 1 gives

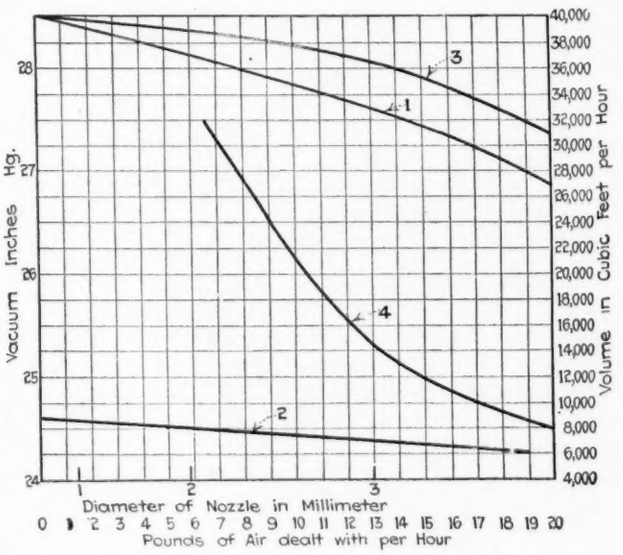
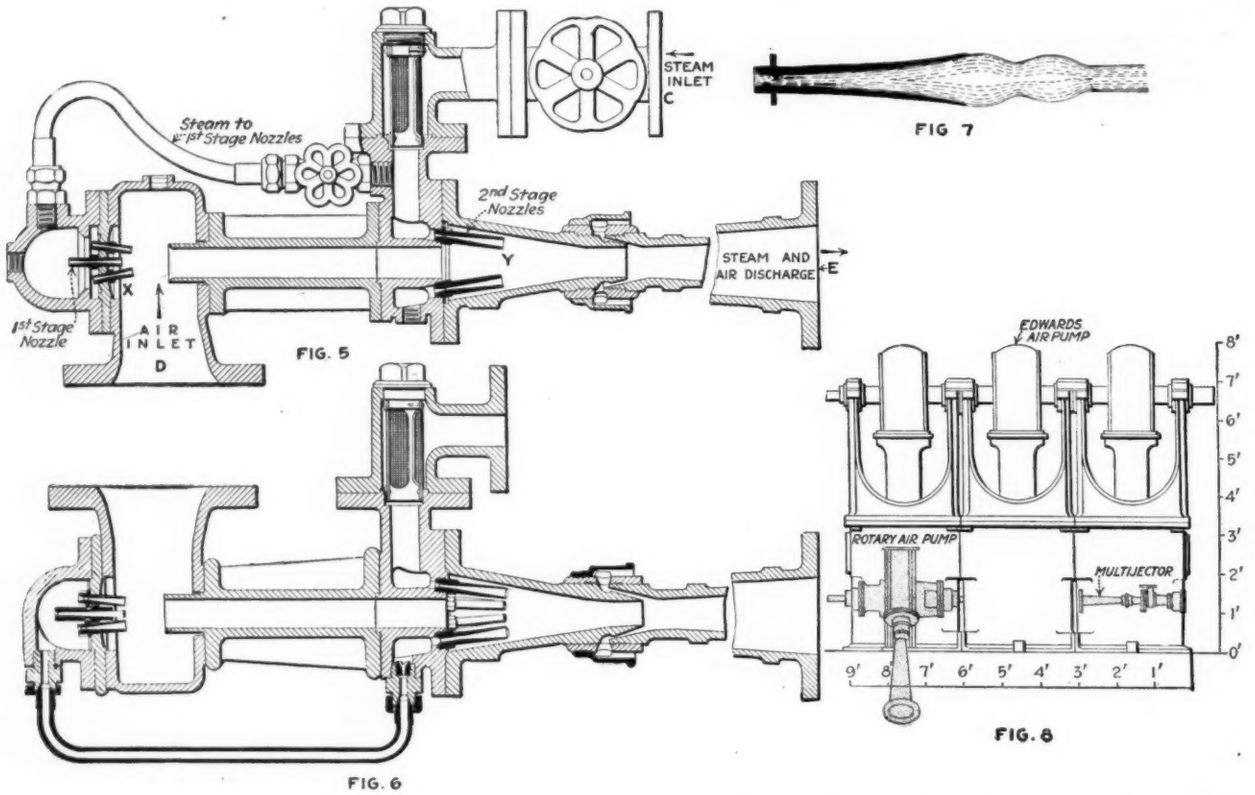


FIG. 4. PERFORMANCE OF AN EJECTAIR

the vacuums obtained with water leaving the condenser at a temperature of 91.4 deg. F. (33 deg. C.), and the auxiliary condenser out of action; curve 2 the volume of air dealt with in cubic feet per hour; curve 3 the vacuums obtained with given air leaks, and the water leaving the main condenser as for curve 1, but with the auxiliary condenser supplied with cooling water at 66.2 deg. F. (18 deg. C.); and curve 4 the volumes of air dealt with under the same conditions. It was calculated that the air coming in with the injection water and at leaky joints amounted to 1.102 lb. per hour (0.5 kg.).

The British Westinghouse Electric and Manufacturing Co., Ltd., Manchester, and the Mirrlees Watson Co., Ltd., Glasgow, manufacture an ejector air pump, under license from the Société Anonyme Westinghouse, Paris and Le Havre, which is another invention of Maurice Leblanc. It is the outcome of many months of arduous research work, during which time innumerable difficulties were surmounted by the inventor, with the result that a really first-class ejector air pump has been evolved. Figs. 5 and 6 show the general arrangement of this apparatus. It will be noticed that the pump is arranged to work in two stages, and the steam is admitted to the second stage of the ejector by opening the stop valve *C*. Immediately *C* is opened, steam fills the annular space behind the nozzle plate, and finds its way into the throats of the group of nozzles *Y* attached to this plate; it then passes along the steam pipe which supplies the first-stage nozzles *X*, which are also

attached to a nozzle plate. The supply of steam in this set of nozzles is controlled by the stop valve on the steam-supply pipe. The pump is connected to the condenser at the branch *D*, which is the air-inlet branch. At the entrance to each of the steam spaces fine wire-gauze strainers are fitted to prevent any foreign matter, which may have primed over with the steam from the boilers, from entering the nozzles, thereby intercepting any stoppage in the nozzle throats, and consequently a loss of vacuum. These nozzles are securely locked to the nozzle plates. The mixture of air and steam is discharged at the mouth of the cone *Y* and led away to the boiler-feed tank, so that the heat units contained in the operating steam can be reclaimed by heating the feed water. To start the pump to work, it is only necessary to open up the steam valve *C*, and the vacuum will at once begin to increase in the condenser or other vessel to be evacuated. When the vacuum gage becomes stationary, the first-stage steam-inlet valve is opened up to bring the vacuum to a maximum. A very ejector, which might be considered negligible. Beyond this, the whole of the heat in the steam can be utilized to heat up the boiler-feed water, and in order to obtain full benefit from the apparatus it is highly desirable to use the discharge from the ejector for heating purposes of some description. Thus both the steam and air can be made to do useful work. In view of this it must not be forgotten that when an ejector of this type is specified as requiring so many pounds of operating steam per hour, this is only the apparent quantity; the actual quantity is really far less, since the great majority of heat units in the steam are still available for further work. The actual heat units recovered can easily be calculated from steam tables, since it is known that the steam and air leave the ejector at a pressure of from 10 lb. to 12 lb. per sq.in. by gage. It will be observed that with a Leblanc multijector an auxiliary condenser is not required, and in this respect it differs materially from the "Berguet" *ejectair*. The employment of an auxiliary condenser has the disadvantage that the total



FIGS. 5 TO 8. MAURICE LEBLANC'S LATEST MULTIJECTOR AIR PUMP AS MADE BY THE BRITISH WESTINGHOUSE ELECTRIC AND MANUFACTURING CO.

Figs. 5 and 6—Two forms of the Leblanc ejector. Fig. 7—Behavior of flow from the nozzle. Fig. 8—Showing comparative sizes of Edwards, Leblanc rotary and the multijector types of air pumps for a given capacity

important feature in this pump is the absence of moving parts. The simplicity of the apparatus is even more remarkable than that of the Leblanc rotary pump.

The advantages claimed are as follow: (1) Extreme simplicity; (2) the small amount of energy required for operating purposes; (3) the high efficiency obtained; (4) ease with which starting can be effected, and the small amount of attention required while at work; (5) ability to produce the highest possible vacuums; (6) stability. In scanning these claims we can pass over the first, which as already mentioned, is obvious; there are simply two steam valves to open. The second deserves some consideration. The operating steam in passing through the nozzles decreases in pressure, and consequently in temperature, and also, after passing through the nozzles, does work in accelerating the velocity of the air, increasing its temperature and compressing it. There is also a small amount of heat lost due to friction in passing through the diffuser portion of the heat units of the steam used in the first-stage ejector, which amount to an appreciable percentage of the total heat units used on the whole apparatus, are dissipated and lost. The makers give this percentage as about 33. Another reason for dispensing with the auxiliary condenser will be apparent from the following. In all steam-operated ejectors one of the difficulties that have to be contended with is the fact that the steam leaves the nozzles at a velocity varying from about 3000 to 3600 ft. per sec., while the velocity of the fluid to be entrained is practically nil. This is the cause of considerable loss of efficiency in any ejector, but if an auxiliary condenser be used the defect is doubled, because the velocity of the fluid to be entrained, which has been imparted to it by the operating steam during its passage through the first-stage ejector, is dissipated and lost as soon as it enters the condenser. The cooling water used on the auxiliary condenser has to be dealt with by the condensate pump, thus increasing the

power absorbed by the plant. When working with surface condensers, this water must be of good quality, as it has to be returned to the boilers.

The third claim relates to efficiency. It is well known that ordinary single-stage ejectors only work well when the compression ratio is as 1: 7, and it is partly for this reason that the Breguet Co. has introduced the auxiliary condenser, so that the vacuum obtaining in this condenser is about 25.6 in. with the barometer at 30 in., the compression being approximately as 11: 76, or, roughly, 1: 7. The over-all efficiency of this plant is, therefore, apparently still further reduced, because air is admitted from the atmosphere into the auxiliary condenser, which is under a vacuum of 25.6 in., and this, together with the air from the condenser, has also to be ejected by the secondary ejector to the atmosphere.

When Professor Leblanc set out to design his ejector he foresaw the possibility of using an intermediate condenser,

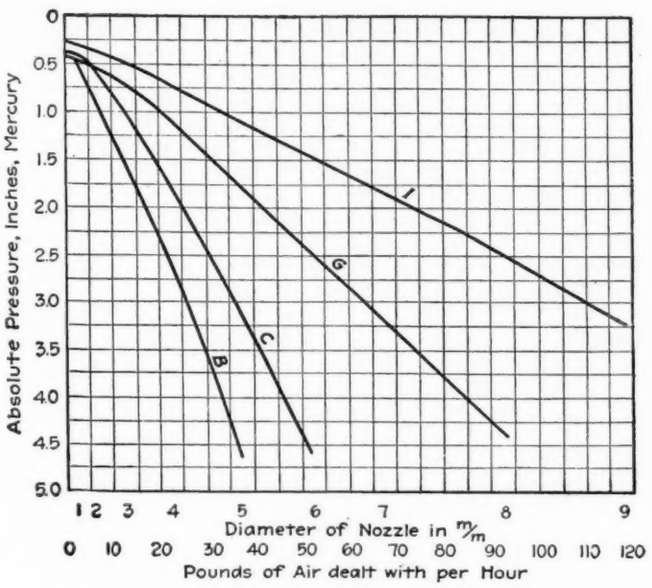


FIG. 9. CAPACITIES OF VARIOUS SIZES OF MULTIJECTOR PUMPS

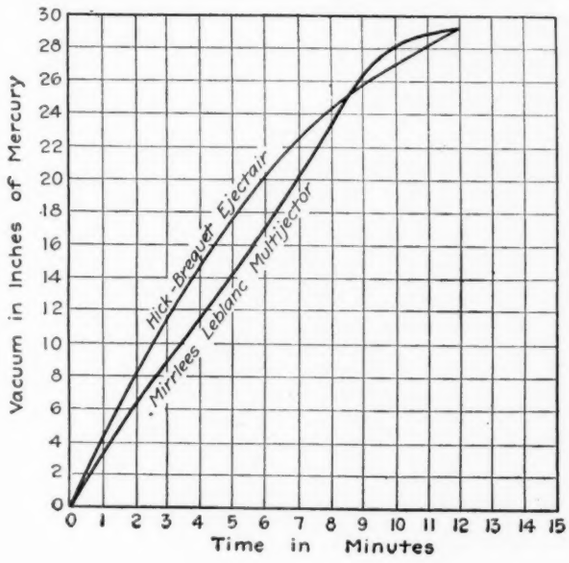

Vacuum in Inches of Mercury
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Hick-Breguet Ejectair
Mirrlees Leblanc Multijector
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Time in Minutes

FIG. 10. TIME REQUIRED TO START HICK-BREGUET EJECTAIR AND MIRRLEES-LEBLANC MULTIJECTOR

but he also appreciated its disadvantages and decided to do without it if at all possible. At the same time he knew that it was essential to use two stages in order to get a stable and efficient ejector. With this end in view, certain steam nozzles were designed on the lines of the formulas of Professor Rateau, and the action of the steam issuing from these nozzles when under high vacuum was directly observed. The result is shown by Fig. 7. The steam issuing from the mouth of the nozzle expands and contracts alternately, ultimately assuming a section of constant area. It was found that a number of these nozzles grouped together gave far better results than a single nozzle of the same throat area as the group of nozzles. The reason for this is to a large extent due to the fact that the alternate increasing and decreasing of the cross-sectional area of the steam stream is minimized by the contact of one steam stream with the next, when groups of nozzles are employed, and this helps considerably to increase the surface available for the entrainment of the air and gases. This entrainment is carried on mainly by friction, and it will be seen that if an appreciable amount of gas has to be dealt with, the frictional surface exposed to the gas has to be as large as possible. It is also inversely proportional to the density of the gas or fluid.

The number and size of the nozzles depends entirely on the space available in the diffuser, and keeping within the limits of workshop practice. The smallest number employed by the Mirrlees Watson Co. is three, each of which has a throat diameter of 1 mm. These are first-stage nozzles. On the largest size of pump, and in the second stage, the number of nozzles is 30, and these have a throat diameter of 5.2 mm. when using operating steam at 90 lb. per square inch.

Professor Leblanc, in his paper of 1911 to L'Association Technique Maritime, says that "the operating steam entrains the air by friction. During entrainment it is the velocity of the steam which is utilized, and not its kinetic energy."

Calling M the weight of operating steam used per second, V its velocity at the outlet of the nozzles, m the weight of air drawn in per second, and W the velocity of the mixture of air and steam, then

$$MV = (M + m)\ W$$

The ratio of the kinetic energy, $\frac{mW^2}{2}$, of the air drawn in to the kinetic energy, $\frac{MV^2}{2}$, contained in the operating steam as it comes out of the nozzles can therefore be stated as

$$\frac{mW^2}{MV_1^2} = \frac{mM}{(M + m)^2}$$

so that when $\frac{m}{M} = 1 \quad \frac{1}{2} \quad \frac{1}{3} \quad \frac{1}{4} \quad \frac{1}{5}$

$$\frac{mM}{(M + m)^2} = 0.25,\ 0.222,\ 0.187,\ 0.160,\ 0.139$$

This shows that if the utilization of the kinetic energy is to be the basis of the design, then for maximum efficiency it is necessary to bring the ratio $\frac{\text{air dealt with}}{\text{operating steam used}}$ as near to unity as possible.

M. Leblanc continues: "We tried to diminish the loss of kinetic energy by producing at the entrance of the diffuser a higher vacuum than was necessary, so that the fluid drawn in came in contact with the operating steam with a considerable velocity. If the efficiency of the diffuser could be brought almost to unity, we could add considerably to the over-all efficiency, but this has been found to be impracticable. Following on this, it was suggested to use puffs of steam after the manner of steam coming out of locomotive chimneys, but the complications involved in making arrangements for stopping the inlet of air during each puff were such that it would have been easier to use a centrifugal compressor. Afterward we tried to compensate for the bad efficiency due to frictional entrainment by transforming heat into kinetic energy in the nozzles. Superheating the

operating steam, although so useful for turbine work, is, however, not good for an ejector, because it is more difficult to effect compression in the diffuser, which outweighs the advantages obtained in the nozzles. The next scheme was to use hot water in the nozzles, but this also proved unsuccessful."

After numerous other trials it was decided that entrainment by friction was most economical, and various types of diffusers and different groupings of nozzles were experimented with, until the present ejector, as shown in Figs. 5 and 6, was decided to be the most suited for condenser work. To go through the various stages in detail which led up to this design would take up too much time. With the form of ejector adopted it has been found that the efficiency of the nozzle is on an average 85 per cent., while that of the diffuser is 70 per cent. It will be seen that this ejector agrees very well with the ideal ejector which Professor Leblanc had in his mind. The first stage, which consists of a small group of nozzles, serves a triple purpose, inasmuch as it effects a certain amount of compression, heats up the entrained air, and gives it considerable velocity, and consequently an increase in momentum. The second stage has a larger number of nozzles, and it is here where the major portion of the work is done, the air being compressed from approximately 26 in. vacuum up to something more than atmospheric pressure. To be more accurate, the steam used in the first stage is about 5 per cent. of the total.

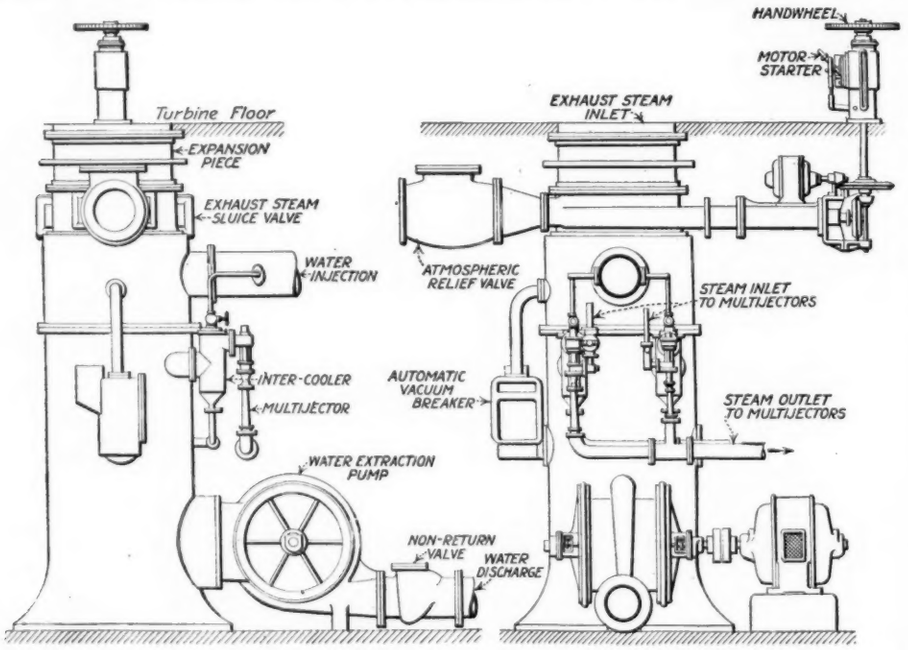


FIG. 11. MULTIJECTORS AT SCOTTISH CENTRAL ELECTRIC POWER CO., BONNYBRIDGE

In support of the fourth advantage which this air pump is supposed to possess, the following figures were obtained on the French torpedo-destroyer "Boutefeu." The turbines were stopped, but steam was on the glands. The volume to be evacuated was about 635 cu.ft. After 1 min. the vacuum was 6 1/16 in., 2 min. 15 in., 3 min. 22 13/16 in., 4 min. 25 7/16 in., 5 min. 26¾ in., and 6 min. 27 7/16 in. The theoretical vacuum corresponding to the temperature of the water, 67.1 deg. F.; namely, 28¼ in., was attained in 11 min. It was also arranged later to allow certain known air leakages to enter the condenser. With a 5-mm. nozzle, which passes 36.2 lb. of free air per hour, the vacuum dropped only ⅜ in. With a 15-mm. nozzle, which is equivalent to 326 lb. of air per hour, the vacuum was 21¼ in. With an inch cock full open it took 11 min. for the vacuum to fall to 12¼ in., at which figure the mercury column remained steady. On closing the regulating valve below the nozzle, the vacuum at once rose and attained the maximum almost immediately. There is a central station near Glasgow where this type of apparatus is at work with a multijet condenser. Sometimes when changing machines there is liability partially to lose the water for a minute or so, but none of the staff ever have to trouble about the ejectors, and as soon as the water comes back again the vacuum at once builds up, and the set is never shut down through failure of the air pumps. As a matter of fact, in the case above stated, it is highly probable that during the period that the water supply to the condenser is very small there is an air passage between the water spaces of the other condensers in the station and the multijet plant which would allow of a very excessive quantity of air getting into the condenser on load. This also shows that stability, the sixth claim, is another salient point. That high vacuum can be obtained is proved by the fact that this apparatus is now being used in the French Navy and mercantile marine, as well as on some land installations for refrigerating purposes, and installations are at work where the maximum vacuum obtained is within 1 mm. of the barometer. For condensers the best results yet obtained by the French Westinghouse company are within 5 mm. of the barometer.

From the foregoing it would appear that this type of air pump is ideal for use on board ship, and particularly in the navy, where space is so valuable and weight of such consideration, and to illustrate this point Fig. 8 has been produced, and represents to the same scale an Edwards air pump, Leblanc rotary air pump, and Leblanc multi-

TABLE I. OFFICIAL TEST OF NO. 18 M. J. CONDENSING PLANT WITH MOTOR-DRIVEN WATER-EXTRACTING PUMP, 1-SIZE "G" AND 1-SIZE "I" MULTIJECTOR AIR PUMP INSTALLED AT THE SCOTTISH CENTRAL ELECTRIC POWER COMPANY, LIMITED, BONNYBRIDGE

Duty—50,000 lb. steam per hour.
Vacuum—28.5 in. (barometer 30 in.).
Injection water—3,800 gallons per minute, temperature 65 deg. F.
Air pump capacity—84 lb. air per hour with guaranteed vacuum and water temperature.
Large ejector to operate condenser alone on loads over one-third and up to two-thirds full load.
Small ejector to work alone on loads of one-third full load and under.
Both ejectors to work on loads over two-thirds full load.

Time	Load				Vacuum		Barometer	Steam Press. on Ejectors		Steam Press. on Turbine	Injection Water		Extraction Pump		
	Volts	Amps.	P.F.	Kw.	Turbo.	Condr.		"G"	"I"		Inlet	Outlet	Press, Gage	Amps.	Volts	R.P.M.
8.45 p.m.	6,350	130	0.75	1,070	28.1	28.2	29.8	120	Shut off	152	..	....	5	58/60	440	480
11.0 a.m.	6,350	266	0.7	2,000	28.5	28.5	29.66	122	130	152	43	70.0	4	60	440	480
12.0 m.	6,350	280	0.7	2,152	28.6	28.5	29.63	122	125	152	43	70.0	4½	59	440	480
12.5 p.m.	6,400	270	0.7	2,090	....	28.2	29.63	Shut	125	152	43	70.0	4½	59	440	480
2.15 p.m.	6,400	325	0.75	2,700	28.2	28.25	29.59	125	160	150	43	72.5	5	62½	440	480
2.45 p.m.	6,450	345	0.76	2,970	28.2	28.3	29.59	125	157	157	43	72.5	5	62½	440	480
3.0 p.m.	6,500	280	0.74	2,330	28.2	28.4	29.6	122½	160	153	43	65.5	4	62½	440	480
3.30 p.m.	6,500	230	0.7	1,182	28.5	28.5	29.6	120	150	154	43	65.5	2	23	440	480

jector for a steam duty on a surface condenser of 40,000 lb. per hour, water at 60 deg. F., vacuum 28½ in., and barometer 30 in. The weights are approximately 20,832 lb., 4480 lb., and 97 lb., respectively. For land work it is equally suitable, and will soon supersede the rotary pump in many power stations. For sugar refineries, chemical and other allied works it should prove exceptionally attractive and take the place of many reciprocating dry air pumps.

It may be advisable to point out here that this pump is purely a dry air pump, so that for surface condensers an additional water or condensate pump is still required, and for jet plants the usual extraction pump.

Fig. 9 shows the air-dealing capacity of various sizes of multijector pumps taken from the actual tests. The maximum vacuum in each case is equivalent to the theoretical, the slight difference at the origin of the curves being due to the different test conditions.

The table of tests, I, is taken from a plant installed at the Scottish Central Power Station at Bonnybridge at a date six months after the plant was put on commercial load. This company has just decided to order another plant, and has specified Mirrlees-Leblanc multijector air pumps.

Fig. 10 shows the time taken to start up a Hick-Breguet *ejectair* and a Mirrlees-Leblanc multijector.

There is no doubt that considerable improvements have been effected in air-pump design during the last few years, nevertheless there is still room for further progress, and it is to be hoped that when the British engineer has time once again for research work we shall have to drop all our present-day notions of efficient air pumps for a type which will render all others obsolete.

Fig. 11 shows installation of multijector air pumps at Scottish Central Electric Power Co., Bonnybridge.

Secretary for Joint Activities of Engineering Societies

For economy of administration and the furtherance of coöperation among organizations representing the profession, the United Engineering Society, the Engineering Foundation and the Engineering Council recently decided to join in one suite of offices in the Engineering Societies' Building and engage a joint secretary. For this position the engineer selected is Alfred Douglas Flinn, now deputy chief engineer of the Board of Water-Supply of the City of New York.

The United Engineering Society was formed some years ago by the National Societies of Civil, Mining, Mechanical and Electrical Engineers to coördinate joint activities and provide for holding property in common. This body acts as the holding company for the four founder societies and is landlord of the Engineering Societies' Building in New York, in which the founder societies have headquarters. In it also is vested the title to the library housed in the same building, which, with the recent addition of the collection of the American Society of Civil Engineers, is now the most important engineering library in the country.

The Engineering Foundation Board was created, as a department of the United Engineering Society, to administer the endowment made by Ambrose Swasey three years ago for the support of engineering research for the benefit of the profession and of humanity. The large sum of money he gave will form, it is hoped, the nucleus to which other gifts will be added.

The last of the three organizations which are to have a joint secretary is the Engineering Council. For years it has been recognized that there were certain activities affecting engineers which could not be properly handled by any one of the individual engineering professional societies. To meet this need there was created during the past summer the Engineering Council "for the proper consideration of questions of general interest to engineers and to the public, and to provide the means for united action upon questions of common concern to engineers."

Mr. Flinn was born in New Berlin, Penn., in 1869, and was graduated from Worcester Polytechnic Institute in 1893. In August, 1895, he became a member of the engineering staff of the Metropolitan Water-Works, Boston, and remained with that organization until 1902. He rose steadily until he became principal office assistant under the chief engineer, Frederic P. Stearns, in charge of designs of the Wachusett Dam and other structures coming under the authority of the Metropolitan system. During the latter years with this organization he also lectured on water-works and sewerage in Lawrence Scientific School, Harvard University.

On leaving the Metropolitan Water-Works Commission, he became managing editor of the *Engineering Record*, and continued in that capacity until August, 1904, when he was appointed general inspector of the Croton Aqueduct Commissioners. About a year later, upon the organization of the Board of Water-Supply of the City of New York, which was established to build the new Catskill Aqueduct and its appurtenant structures, he became department engineer in charge of the headquarters department. He continued as department engineer until August, 1914, when he was made deputy chief engineer. He has continued in that capacity until his election to the secretaryship referred to in this article.

ALFRED DOUGLAS FLINN

Mr. Flinn brings to his new position a broad executive and organizing experience. He is a member of the board of direction of the American Society of Civil Engineers and chairman of its committee on publications.

In relation to modern engineering no one man can be expected to possess a working familiarity with the whole. In a particular sense all engineers are specialists, though many have a more comprehensive grasp than others. To produce the best it is above all things essential that our knowledge exceeds the demands of the task in hand. It is therefore urged that the most effective method by which to acquire the needed broadening of knowledge is by continual reading and study; otherwise—notwithstanding individual attainments—the best become "outsiders" and back numbers.

Dr. Garfield on the Fuel Situation*

I shall be duly appreciative, gentlemen, if I may be privileged to answer questions, as far as I am able, rather than to undertake to set forth to you matters concerning the Fuel Administration.

The United States Fuel Administration was appointed by the President of the United States in accordance with the provisions of an act of Congress known as the Lever Act. Food and Fuel were provided for by that same act. In the 25th Section of that act, provision was made for the Fuel Administrator. The President has given the Fuel Administrator all the power that he himself possesses under the act.

In setting up an organization, the difficulty was one that you gentlemen will appreciate, who have at any time engaged in projecting an organization to carry out some large purpose, especially if the carrying out of that purpose has run with the period, or run with the activity of organization. To build your house and live in it at the same time is no easy task. We were compelled to adopt a working hypothesis to govern us in our organization and to proceed upon that hypothesis, in the hope that our plan would be a workable one.

Organization Scheme

Briefly, we set up the Federal control here in Washington, appointed the State Fuel Administrators in each of the states of the United States and in the District of Columbia, requested each one of those fuel administrators in turn to appoint county and municipal administrators, vested in the state fuel administrators full power to distribute the coal within the state, made it clear that so far as the county and municipal administrators and their committees were concerned, the administration here at Washington delegated full power, both in appointment and in control to the state fuel administrators. It was, you see, in a measure, a United States—there was the Federal, the state, the county and the municipal administration.

I am the more impressed with the significance of this organization just at the present time, because in my native state (Ohio) there has been some difficulty reflected in the morning papers, owing to the fact that Governor Cox, with an admirable zeal for distributing coal to the people and institutions of Ohio, has crossed the lines of the Federal Fuel Administrator, Mr. Johnson, thinking thereby to accomplish a good purpose. But it is very easy to see that if coal upon the tracks consigned in one direction is taken, as it may be, under the law, by the representative of the United States Fuel Administrator and diverted to an immediate need, it is impossible that there shall be anything other than confusion, if some other authority runs across that plan and undertakes also to divert coal.

Let me touch upon one policy that is reflected in the organization, and, at the same time, has intimately to do with meeting the problem presented. The United States Fuel Administration isn't responsible for the way coal is deposited in the earth. If we take the right view of it, I think we will admit that mankind is there beholden, as in all other things, to the Creator of the Universe. The coal is deposited throughout the United States in various regions, and obviously to allow our State Administrators to draw upon that coal and limit them, won't do, because in a place like Ohio, for instance, where there is coal in abundance, the State Administrator would be able to supply the people of Ohio abundantly, and might, if he were selfishly disposed, neglect those who were in states in which no coal was deposited. Therefore, from the beginning, I have pursued the plan that in governing production and distribution from the mines, the Federal, that is, the United States Fuel Administrator, must be the director. On the other hand, when it comes to distributing the coal within the borders of the state, that is a matter much better left to the State Fuel Administrator.

Speaking of bituminous coal, we are this year producing something like 50,000,000 tons more coal than we produced last year, and last year was a record year. Some of you will then say: "Why is there a shortage?" Because we needed 100,000,000 tons more than last year. The extra 50,000,000 tons which we needed, but have not had, amount to the same thing as if there were a shortage of supply. The extra demand, as you will appreciate, comes from the fact that the United States is at war, that our manufacturing enterprises must be supplied with coal, that the railroads of the country, taxed beyond their powers, must have more coal to operate as they are now operating, to say nothing of the normal increase in the call for domestic coal.

There are three factors entering into the production—first, the operators, then the mine employees, and third, the railroads. Unless each one of those is working at efficiency, we will not have maximum results in output.

About the time the Federal Fuel Administrator was appointed, the bituminous interests of the country got together and formed a national organization. Undoubtedly that organization has desired things which the Federal Fuel Administrator hasn't been able to furnish; possibly that organization may entertain ideals of policy that do not appear in the same light to the Federal Fuel Administrator, but if that latter is true, I haven't yet discovered it.

A large part of my time was spent during the first two months, and indeed much of my time is still occupied, with bringing together operators and representatives of labor, who, in certain fields of the country, are not able quickly to adjust their differences, and I have just one theme that I always present to those gentlemen when they come together, and it is this: Whatever our controversy, wherever the right lies, make sure that production continues and be not interrupted by reason of your dispute. That theme cannot be overemphasized.

Labor Has Done Its Part

I also wish here to pay tribute to labor, because the leaders, the conservative element in labor, has caught the idea not because it was enunciated by me (because I was only one voice saying the same thing), but because it is the spirit of our people at the present time that in prosecuting this great war, in meeting the emergency which we are called upon to meet because of it, labor, realizing these facts, has come forward in the very best of spirit, saying that it will not permit labor to cease to do its part. Wherever there is a failure in that program, it is because of the inevitable radical element that we find in every business in every country.

Now, I am very far from saying that no good comes out of radicalism. Human nature is so constituted that there are always some at the extreme right and some at the extreme left of every proposition; but in a time of emergency, when action is necessary, when we must spend less time in deliberation, when it is not feasible to educate everybody, as it is in times of ordinary conduct of affairs, it is perfectly obvious that the extremes must be brought together and action taken, even though the conservative thinks that we are going to wreck and ruin, and even in spite of the fact that the radical believes we are not going nearly far enough. So then, the radical element in the whole field has been a disturbing element, but it has been held in check by the great mass of the workingmen in the coal fields, and with relatively slight interruptions production has gone forward.

Now, it is a significant fact, speaking of the anthracite field, that with the total amount of labor in normal times, something like 175,000 men and boys at the mines were reduced by 25,000 because of the draft and because of the fact that employment elsewhere has appeared more attractive. But in spite of the fact that there are only 150,000 men and boys laboring in the anthracite field this year, against the 175,000 normally, the anthracite mines have produced something like 20 to 22 per cent. more coal than they produced a year ago. That plainly is a

*Address delivered before the Editorial Conference, Washington, D. C., Thursday, Dec. 13, 1917.

tribute both to labor and to those who are conducting the mines.

There is an element in human nature that we ought not to lose sight of, and though it is painful to comment upon it, gentlemen, it is necessary to comment upon it; the selfishness of human nature, the disposition, to use a common phrase, to hog things. Now, there has been a great deal of that sort of thing this year. It has extended into the households, people buying more coal than they quite needed; it has found its way more naturally into the factories, anticipating an increase of business, and the result is that some, many indeed, have more coal than usual, some have more coal than they need for the entire year, and some less provident, possibly because they could not provide the store ahead, are without coal.

Discussion

J. Chase: Are our rivers being used to their fullest extent in the shipment of coal at the present time?

Dr. Garfield: The rivers are not being used to their fullest extent; one may say the same thing as to the railroads, but in the case of the rivers, the accustomed channels for the distribution of coal had been provided otherwise. Now, whether the railroads have in times past, by the law of protection, gotten more than their due share of the coal transportation, I am not prepared to say. I know that when it came to the question of using the rivers we were not equipped to make the maximum use of them that should have been made. And, of course, there was no time to provide the extra equipment. That is being provided for more and more, however, now.

Mr. Frost: Why is it that coastwise towns like Providence, R. I., have to pay more for coal than interior towns like Worcester and Springfield?

Dr. Garfield: Because the freights by water have gone up largely because of the fact that the ocean-going tugs have been requisitioned by the navy.

May I say in that connection that the Governor was in my office and I gave him the information (Governor McCall, I refer to), that I have just arranged within a few days with the Secretary of War and with the Secretary of the Navy coöperating, and with E. N. Hurley, of the Shipping Board, that we shall have the supply of ships necessary to transport our coal by water.

The Secretary of War stated to me that if it became necessary to do so, he would detail mine layers, too good for the operation, as a matter of fact, but nevertheless quite sufficient, to pull the barges around from the tidewater ports here to New England. Also Mr. Hurley is directing that certain boats brought down from Montreal shall be put into the New England trade; and further than that, I am making a request (this looks forward to another season) that the new shipbuilding corporation shall build for us tugs that will be ready for service by the time next season comes around.

Mr. Williams: Regarding the matter of utilities, I understand that they are put in a priority class for consumption and not for storage. I read in the paper this morning that two plants operating in large industrial centers are without a sufficient supply of coal and have asked industries to close down. What will the Fuel Administration do with utilities in that matter, and to what extent will this supply be for current use?

Dr. Garfield: The moment we receive the information that a public utility is out of coal, or in danger of being out of coal within a few days, we issue the orders to send coal to that utility.

Mr. Williams: Well, the Washington papers stated that in the Baltimore and Pittsburgh sections the Government had to request industries to close down—industries using electrical power—because of the shortage of coal. I know that the priority order puts the utilities in a class where they can get coal for current consumption (that was issued by the Food Administration, I believe); now, the point I'd like to ask is how soon can these companies get coal and to what extent will they be kept in a supply of coal, so that such an emergency will not arise and so the shipyards will not be closed down?

Dr. Garfield: Any utility that will inform us of its impending lack will receive supplies of coal; that is, we will issue the orders right off to divert to those utilities enough coal to keep them going.

Now, a severe spell of weather, such as we have just had, may defeat the arrival of that coal in time, but all we can say about that is that that is liable to happen any season, and furthermore that the utility should speak far enough ahead and speak in the right form.

A mistake is made by not coming to the right place. If the utility will let the State Fuel Administrator know the necessity, and the State Fuel Administrator will thereupon inform this office here, immediately orders will be sent out to certain specified mines.

A. L. Findley: May I ask, Dr. Garfield, as to the status of the proposal to pool quantities of the mines?

Dr. Garfield: The Ohio pool is the one that has, so to speak, the best stock. Homer Johnson, the Fuel Administrator for Ohio, brought the suggestion to me (whether it originated with him or with the operators in Ohio, I can't say), about the Ohio pool. It is a terminal pool, as distinguished from a pool at the center. It is working out, so far as I can learn, well. It is only in the early days of its organization.

Mr. Findley: I wondered whether a manufacturer who had a partial supply of fuel for his gas producers, for example, and for his byproduct too, and ordinarily bought a supply of coal in the market, whether his own supply of coal would go into a pool supply in case there was a pooling, or whether the pooling of the coal would be a pooling of the merchant supply, or whether the mine or his company would have to throw supply of coal into the pool.

Dr. Garfield: The whole supply would go from the shipper; that is, the operator, the mine would go into the pool.

Mr. Findley: If you were a producing consumer of coal your own coal would go into the general pool and you would only get perhaps a part of the coal that you yourself produced; that is, your normal supply might be reduced?

Dr. Garfield: I am not informed whether those who are producing coal entirely, exclusively for their own use, have consented to go into the pool or not. Perhaps Mr. Morrow, knows. Have you any such, Mr. Morrow, in the pool?

Mr. Morrow: I can't answer that specifically, but the point of his question, so far as it relates to byproduct coal, may be answered in this way: Byproduct coal needed in any plant will not be moved. That coal ordinarily moves in solid trainloads, and will not be interfered with. That refers to companies who have their own mines. They are not included in the pools now, but later on may be included.

W. C. Baker: Mr. Morrow in his address to us emphasized the effect of car shortage in reducing the output of the mines, and the question was being discussed as you came in, to what extent various causes were operating to produce that car shortage. I'd like to inquire to what extent there is congestion in the tidewater and other important terminals. Is it not a fact that a large amount of freight is tied up in the terminal yards and makes it very difficult to have coal cars promptly and ties them up too long a time in their shipment, so that they are slower getting back to the mine?

Dr. Garfield: Undoubtedly that contributes to it. When a crowd of vehicles and cars are tied up at a street corner, it is difficult to determine which car or vehicle is producing the trouble—they are all producing it. And yet, it is true that the congestion at the terminals is one large contributing factor, perhaps the largest of any.

Mr. Taylor: To what extent does the authority of the Fuel Administration extend in ordering a mine to ship coal to the transportation company?

Dr. Garfield: I think it extends a good deal further than some other. The reading of the act is that the Fuel Administration has control of the apportionment and shipping of coal—I haven't hesitated, therefore, but another section states that all the agencies of the Government shall perform such service as the Fuel Administrator may require of them. If the railroads were controlled by the Government, the task would be simple, I could then issue the order. Railroads being in private hands, I can ask for priority orders and make requests of them, but I haven't any power to force the railroads to do a thing asked for.

M. C. Robbins: Mr. Morrow expressed the opinion that the reason for the coal shortage is the lack of cars by the railroads. You mentioned an important reason for the coal shortage: the demand for 50,000,000 tons of coal to be produced. From other sources, it has been said that the fixing of the low price for bituminous coal has discouraged the output of a great many mines. I'd like to ask if all three of these things are the cause, or if there is any difference in importance in these three things.

Dr. Garfield: Undoubtedly the fixing of a lower price than the operators had hoped would be fixed, played its part, and yet I can't prove it. It looks as if the proof went the other way. The President's order went out on Aug. 21, and the second order on Aug. 23. The reports of production for the weeks beginning with, I think, the 18th and straight along for the next few weeks, increased each week; there was a larger production each week than the preceding week, and a larger production than the year before. So it is difficult to say that the appearance of the President's order fixing the price halted production. In fact, only in one week since the President's order has come out, was there a drop that was materially below the production of last year, and the average is considerably above.

Mr. Frost: I am in some way connected with the public schools of our city. Tomorrow we have to determine whether or not we shall declare a vacation for the winter for the purpose of conserving coal. I'd like to know what Dr. Garfield's opinion is on that important matter.

Dr. Garfield: My judgment about that is that it is very poor economy, unless we are actually forced to do it, in a community to shut down schools.

R. Sherman: Can you tell us anything about how much coal is saved by cutting out electric illumination at night?

Dr. Garfield: I wish I could give you accurate figures. I am disappointed in the results. I think the result was less productive of saving than we expected it would be, and I shall change the order; but I don't propose by any means to give up the idea of saving in the United States on signs and white ways. We want to interfere less with business and accomplish better results.

Mr. Baldwin: Dr. Garfield, I'd like to present this matter, where an industry depends upon its own power for this service, but has difficulty in obtaining its coal, and the proposition is made by the public service corporation for shutting down its plant; are the chances better for the company to unite with the public-service corporation engaged in furnishing electricity for power than to depend upon the Fuel Administrator for the necessary coal to keep the plant running, when, as a matter of fact, this same coal could be burnt in either instance?

Dr. Garfield: I doubt if one could answer that clearly, except in a specific case. I should say, nevertheless, attempting to answer it generally, that there is more economy in working through public utilities; but if, on the other hand, your public utility is already overloaded, obviously you have got to resort to some other way. If your public utility is so located that it has peculiar difficulty in getting its coal supply, one would answer the question otherwise, so that while I would answer it in that way in general, I would have to recognize the existence of several exceptions.

Mr. Tipples: I'd like to ask if the price had been higher and production at the mines greater, would it be of any value, under present conditions, or are we producing all the coal that we can handle?

Dr. Garfield: That question is a very pertinent one, because it is obviously true that if the roads are now clogged and can't deliver what we have on the rail, how much worse position would they have been in if we had produced more coal from the mines. I think that the transportation system of the country, as it stands today, is not able to take care of more than is now being produced. I think it may be possible to transport more under the arrangements which are now in the making.

Mr. Stone: Is a comprehensive plan in the making providing a release of ocean tugs for coastwise and Lake traffic to meet conditions next fall and winter?

Dr. Garfield: Yes, it is.

Mr. Black: To what extent have the public-service commissions been willing to coöperate with plans of your department in regard to the economy suggested by you for public utilities?

Dr. Garfield: No sufficient return has been received yet to answer that. So far as I know, there is no disposition to do other than coöperate.

Mr. Lockwood: Has anything been done to increase the production of power for industries by use of water power?

Dr. Garfield: No efforts are being put forth to introduce any substitutions of that kind, because they won't meet with the present emergency. Where there are hydro-electric operations, however, the request, of course, is that they depend as far as possible upon the water power, and indeed they would do it without our asking, because it is a cheaper way. There are many good plans of various kinds that could be introduced if we had time to introduce them. I want to say in that connection that report came to me last week that a good many of the hydro-electric operations in the country (this person happened to have come from the South) have stocked up with more coal than they need under the circumstances, so I suspect that that is one of the places where coal has been taken on in larger quantities than it need be.

A. I. Findley: Do you consider the coal shortage more difficult than the fuel-oil shortage just now, whether you are considering substituting fuel oil for coal in industry.

Dr. Garfield: I should say that fuel oil is in the long run less serious; the coal is more serious because it happens that our large munitions factories are depending upon coal, not for fuel oil—that is, in larger proportion.

Essex Power Plant Shut Down

At 5:30 Wednesday morning, Dec. 19, one of the instrument potential transformers on one of the 25,000-kv.-a. units (No. 1 unit) in the Essex Power Plant of the Public Service Electric Co., Newark, N. J., broke down and caused a very destructive burnout of the generator cables between the machine and oil switch. Although the trouble amounted to practically a short-circuit of the generator terminals, the unit was not injured. Nevertheless, the nature of the burnout made it impossible to get the machine back into service.

At the time of the trouble the two 25,000-kv.-a. units, which are at present installed in this station, were in service and carrying a load of 36,000 kv.-a. When No. 2 unit picked up the overload, its turbine developed a knock that was considered serious enough to shut the machine down so as to investigate the trouble rather than take a chance of more serious developments. This left the station dead and compelled the company to reduce its system's load by 25,000 kw., which could not be taken care of by the other plants on the system. By putting jumpers from No. 1 unit to the switches on No. 2, No. 1 machine was back into service by 2:30 in the afternoon, and by 4:30 the next day the trouble was cleared up and both machines back into service, which is a remarkably short time to make repairs of this magnitude.

When No. 2 turbine was opened, what appeared to have been a rub on one of the wheels was the only indication of what had caused the knock. This was remedied and the turbine put back into service without further developments.

The next morning after the accident at the Essex Plant, the company had to curtail its service for a short period at its Marion plant, owing to low steam pressure, on account of the heavy overload this plant was carrying during the peak period and the poor quality of coal that they have been forced to use.

The company, like many other central stations in this country, has all its spare capacity contracted for, in an endeavor to meet the heavy demands placed upon it by the many new industries that have grown up to supply the war needs of the nation. This, combined with the difficulties of obtaining deliveries of new equipment and an adequate coal supply, has brought about anything but an assuring condition in many cases.

At the present time a 35,000-kv.-a. unit is being installed at Essex and will be in service in a few weeks. This will give the company reserve capacity for some time to come and guarantee against a recurrence of the recent embarrassment.

Obituary

Charles J. Klein, designing engineer for the Cutler-Hammer Co., and a prominent electrical inventor, died suddenly at his home in Milwaukee, Wis., on Sunday night, Dec. 16. Mr. Klein was born in New York City 55 years ago and went to Milwaukee from the New York office of the Cutler-Hammer Co. in 1908. He was an intimate friend and co-worker of Thomas Edison for many years. He is survived by a son and a sister.

Frank Martin, well-known as an engineer and contributor to "Power," died on Christmas Eve of pneumonia after an illness of two weeks. As an operating engineer, Mr. Martin had a full experience. He was a master electrician in the United States Navy, having been stationed at the Brooklyn Navy Yard. For a number of years he was chief engineer of the Hard Rubber Co., College Point, N. Y., and served for a period as master mechanic of the American Thread Co., Willimantic, Conn. A few years ago Mr. Martin went to Honolulu as chief turbine engineer for the Marconi Wireless Telegraph Co. He returned to the United States about two years ago, after which he took a needed rest. At the time of his death he was first assistant chief engineer for the New York Steam Co. He also held the rank of chief machinist's mate in the Naval Militia when he died. Mr. Martin was an honorary member of Brooklyn No. 8, N. A. S. E., and a Master Mason, Oceanic Lodge, Honolulu. He is survived by his wife. Death came while Mr. Martin was in the New York Hospital. Services were held Friday, Dec. 28, at Stephen Merritt Chapel, Eighth Ave., New York City.

Personals

W. R. Jennison has been appointed Southeastern representative of the Hoppes Manufacturing Co., of Springfield, Ohio, with offices at 407 Bisbee Building, Jacksonville, Florida.

Robert E. Dillon, who has been in charge of the steam-testing division of the standardizing and testing department of the Edison Electric Illuminating Co., of Boston, has been appointed assistant superintendent of the generating department.

Fred Greanoff, formerly assistant superintendent at the Duluth Boiler Works, has resigned to engage in a similar business of his own at Buffalo, N. Y. Before leaving, Mr. Greanoff was presented with a gold watch and chain and stickpin by the employees of the Duluth Boiler Works.

J. C. Bannister has been made a vice president of the Walworth Manufacturing Co., of Boston, Mass. He was successively foreman in the tapping department of the Haxton Steam Heater Co., at Kewanee, superintendent of the pipe-finishing mill and chief engineer; superintendent of the Kewanee Boiler Co. and later manager of the Kewanee works.

D. J. Angus, who recently purchased an interest in, and associated himself with, the Esterline Co., of Indianapolis, Ind., as treasurer, has taken over the responsibility of the engineering department and of the design and development of new lines of instruments and apparatus. Prior to his connection with the Esterline Co., he was associated with J. W. Esterline in consulting-engineering work.

C. H. Andrews, assistant to president and chief engineer of the North Carolina Public Service Co., Greensboro, N. C., has been appointed general superintendent of the Southern Utilities Co., which corporation operates electric, gas and ice properties throughout Florida, under the management of the J. G. White Management Corporation, New York City. He will assume his new duties on Jan. 1.

L. L. Hebberd, for the last four years associated with the consulting engineering firm of Vaughn & Meyer, of Milwaukee, Wis., in charge of the mechanical-engineering department, is now with the Consolidated Water Power and Paper Co. as mechanical engineer and superintendent of steam power. His headquarters at present are at the Interlake Pulp and Paper Co., an affiliated company, at Appleton, Wisconsin.

Engineering Affairs

The Society of Automotive Engineers will hold a meeting in New York on Jan. 10 and one in Chicago on Feb. 1. Four engineering authorities on aviation—Maj. Jesse G. Vincent, father of the Liberty engine; Col. Clarke, Capt. Howard Marmon and H. M. Crane—will handle that part of the subject at the New York meeting. The Chicago meeting, which will be held at the Hotel Sherman, will be devoted entirely to farm-tractor subjects, and the war dinner will be held the same evening at the New Morrison Hotel.

The Engineering Society of York, Penn., elected the following officers for the ensuing year at its recent annual meeting: President, James Rudisill; vice president, Chauncey D. Bond; secretary, M. Haller Frey; treasurer, Harold A. Russell; directors, George A. Jessop, Charles L. Berger and Howard J. Longenecker. The annual reports show that considerable progress has been made during the past year and there has been a considerable increase in the membership of the organization.

The Evening Students Association of the Polytechnic Institute, of Brooklyn, N. Y., held its third annual smoker on Saturday, Dec. 22, in the gymnasium of the institute. There were fully three hundred in attendance. Chairman Price, of the entertainment committee, outlined the purposes of the association. Prof. Charles A. Green, director, welcomed the audience in a brief speech. The entertainment included boxing, wrestling, tumbling and humorous addresses by John Rogers, Doctor Foy and Jack Armour, of "Power." Fred Bucholtz was the master of ceremonies. Refreshments were served.

The American Association of Engineers held a meeting at Washington on Dec. 14, the object being to form a coöperative movement to assist the Government to secure desirable and qualified technical engineers. Among those present were: Admiral F. R. Harris, Admiral Baird, Major Zimmerman, of the Engineers' Depot, and Major Harrison, Capt. D. S. Hays, of the U. S. Engineer Corps, described how the organization rose from a small beginning to its present size. The following were elected officers of the Washington Chapter: President, F. R. Weller; first vice president, A. S. Grossberg; second vice president, Harry Stevens; secretary, Capt. D. S. Hays; treasurer, O. M. Sutherland. The association is a member of the Chamber of Commerce of the U. S. A., and is coöperating with all the chambers of commerce throughout the country.

The Society of Automotive Engineers will hold a special meeting on the afternoon and evening of Jan. 25. The afternoon session will be held at the society's headquarters, 29 West 39th St., New York, and the dinner and evening session will be held at the Automobile Club of America, 247 West 54th St. The afternoon session will be devoted to the consideration of engines for motor boats; one of the subjects will deal with the Diesel engine and the other with engine design for submarine chasers, etc. James Craig, of the Craig Engineering Co., will speak on "Developments and Improvements in the Diesel Engine in the United States." E. A. Riotte, of the Standard Motor Construction Co., will give an address on "Engineering Fundamentals in Low-Speed Engines for Motor Boats." In the evening Erwin Chase, engineer of the Submarine Boat Corporation, will speak on "Equipping Our Transports with Motor Boats." Henry R. Sutphen, of the Submarine Boat Corporation, will give a talk on standardization in boat construction. It is planned to have a special movie film prepared for the evening, showing submarine chasers, coast patrols and other boats which use the explosion-type engine.

Miscellaneous News

Ordnance Department Wants One Hundred Draftsmen to fill positions paying from $800 to $1800 per year. Civil-service examinations for these positions will be held in Chicago, Jan. 8, 9 and 10. Positions will be permanent. Applications should be filed with Milward Adams, Secretary Civilian Personnel Committee, Ordnance Department, offices State Council of Defense, Chicago, Illinois.

The Goulds Manufacturing Co., Seneca Falls, N. Y., has put into effect, beginning Jan. 1, 1918, a bonus system whereby all hourly, piecework and salaried employees rated at $40 a week or under, will receive quarterly a bonus of 10 per cent. on their total salary for the previous three months. This bonus is contingent upon a stipulated amount of time being put in at actual work during the year, and is aimed to encourage full-time work.

The Little Miami Light, Heat and Power Co., of Cincinnati, Ohio, has instituted condemnation proceedings under the right of eminent domain for rights for a $1,500,000 hydro-electric system in the Little Miami River district between Plainville and Morrow. It intends to build fifteen dams on the Little Miami River. There will be no lock system in connection with these, the only openings to be fish chutes. The corporation expects to develop 10,000 hp., which will be used outside of the City of Cincinnati proper. It also proposes to develop other territory bordering along the river, a distance of 30 miles.

The Woman's Committee for Engineer Soldiers has been formed in Washington, D. C. Mrs. William M. Black, wife of General Black, Chief of Engineers, is president; Mrs. Charles Keller, vice president and chairman; Mrs. W. W. Harts, secretary; Mrs. Ulysses Grant, 3rd, treasurer. The object of the Woman's Committee is to see that no engineer soldier leaves this country without the proper knitted garments and to send garments to those already "over there." The National Committee in Washington is to be headquarters for units all over the country and by purchasing yarn in large wholesale quantities should be able to get better prices and deliveries. The dues are $1 a year, and a very earnest appeal is made to every man and woman interested in the engineers of the Regular Army, National Army, the Railroad, Forestry, Camouflage, or Labor regiments, to join this organization or to send contributions of money for wool or finished knitted garments, to supply these hundred thousand men. Address Mrs. William M. Black, 1730 I St., N.W., or Mrs. Ulysses Grant, 3rd, 2204 R St., N.W., Washington, D. C.

To Train 50,000 Men for New Ships—The "Gov. Dingley," a coastwise passenger steamer until recently in the Boston-Yarmouth, N. S., service, has been chartered by the United States Shipping Board Recruiting Service, of which Henry Howard is director, with national headquarters at the Boston Custom House, for a training ship for crews for the new merchant marine. She is the second training ship chartered here, the first one being the "Calvin Austin," which recently went to Halifax as a relief ship as her first mission for the Shipping Board Recruiting Service. Like the "Calvin Austin," the "Gov. Dingley" will have her base at the new Federal Wharf at East Boston. She will accommodate a "class" of 500 seamen, firemen, oilers, water tenders, cooks and stewards, who will be given intensive instruction by experts to fit them for places in the new merchant marine. The training of 50,000 men on training ships during the next year will be directed by the new Sea Training Bureau, with headquarters at the Boston Custom House, and with Capt. Eugene E. O'Donnell, supervising inspector, Fifth District, U. S. Steamboat Inspection Service, as supervisor. Capt. James P. Stevenson, until recently marine superintendent of the United States transport service, is executive head under Captain O'Donnell. Headquarters of Mr. Howard, at the Boston Custom House, are being flooded with applicants for enrollment on the new training ships.

Trade Catalogs

Esterline Graphic Efficiency Instruments. The Esterline Co., Indianapolis, Ind. Booklet No. 370. Pp. 12; 6 x 9 in.; illustrated.

Safety Switches and Cut-Outs. The Palmer Electric and Manufacturing Co., Boston, Mass. Bulletins M13 and M17; pp. 4; 6 x 9 in.; illustrated.

New Clutch Drive Rochester Automatic Lubricator. Greene, Tweed & Co., 109 Duane St., New York. Booklet showing different installations of this lubricator.

Class "Y-C-E" Duplex Direct Connected Electrically Driven Air Compressors. Nagle Corliss Engine Works, Erie, Penn. Bulletin No. 30. Pp. 12; 6 x 9 in.; illustrated.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Dec. 28, 1917	One Year Ago	Dec. 28, 1917	One Year Ago
Buckwheat ..	$4.60	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.10	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	3.90	.....	.....	.....
Barley	3.60	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Bituminous not on market.

	F.o.b. Mines*		Alongside Boston†	
	Dec. 28, 1917	One Year Ago	Dec. 28, 1917	One Year Ago
Clearfields....	.....	$3.00	.....	$4.25—5.00
Cambrias and Somersets..	.....	3.10—3.85	.....	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.90 a year ago.

*All-rail rate to Boston is $2.69. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Dec. 28, 1917	One Year Ago	Dec. 28, 1917	One Year Ago
Pea	$5.05	$4.00	$5.80	$5.50—5.60
Buckwheat ..	4.90—5.00	2.75	5.75—6.00	4.75—5.00
Rice	3.75—3.95	2.20	4.75—5.00	3.00—3.25
Barley	3.25—3.50	1.95	3.70—3.95	2.25—2.50
Boiler	3.50—3.75	2.20	4.00—4.50	.....

Bituminous smithing coal, $4.50—5.25 f.o.b.
Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Harbor	Mine
Pennsylvania	$3.65	$2.00
Maryland	3.65	2.00
West Virginia (short rate).....	3.65	2.00

Based on Government price of $2 per ton at mine.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide		Independent
	Dec. 28, 1917	One Year Ago	Dec. 28, 1917	$2.90	One Year Ago
Buckwheat ...	$3.15—3.75	$2.00	$3.75		$4.15
Rice	2.65—3.65	1.25	3.65	2.15	3.35
Boiler	2.45—2.85	1.10	3.55	2.00	.....
Barley	2.15—2.40	1.00	2.40	1.90	2.35
Pea	3.75	2.80	4.65	3.70.	.....
Culm	....	....	....	....	1.25

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.65—2.80	$3.10—3.25
Mine-run	2.40—2.55	2.85—3.00
Screenings	2.15—2.30	2.60—2.75

Smokeless Coals	So. Illinois, Pocahontas, Pennsylvania and West Virginia	Hocking, East Kentucky and West Virginia Splint
Prepared sizes	$2.60—2.80	$3.05—3.25
Mine-run	2.40—2.60	2.40—2.60
Screenings	2.10—2.30	2.10—2.30

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Dec. 21, 1917	One Year Ago	Dec. 21, 1917	One Year Ago	Dec. 21, 1917	One Year Ago
6-in. lump..	$2.80	$3.00	$2.80	$2.60	$2.80	$2.25–2.50
2-in. lump..	2.80	....	2.80	....	2.80	2.00–2.25
Steam egg...	2.80	3.00	2.80	....	2.80	2.00–2.25
Mine-run ...	2.55	2.75	2.55	2.60	2.55	2.00–2.25
No. 1 nut...	2.80	3.00	2.80	2.50	2.80	2.00–2.25
2-in. screen.	2.30	2.75	2.30	2.50	2.30	2.00–2.25
No. 5 washed	2.30	2.75	2.30	2.75	2.30	2.00–2.25

Williamson-Franklin rate St. Louis, 87½c.; other rates, 72½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona....	2.15	2.40	1.90
Black Creek, Cahaba ...	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ark., Marianna—The Citizens Service Co. has applied for permission to build an electric-lighting and power plant here.

Ky., Whitesburg—W. C. Daniels & Son are having plans prepared for the erection of a transmission line from here to Mayking.

Mo., Appleton—City plans election in January to vote on a $15,000 bond issue to improve its electric-lighting plant. W. B. Rollins & Co., 209 Railway Exch., Kansas City, Engrs.

N. J., Bloomfield—The Power Specialty Co., 111 Bway, New York City, has had plans prepared for the erection of a new plant on Locust Ave., here. Estimated cost, $31,000.

N. J., Jersey City—Swift & Co., Union Stock Yards, Chicago, has had plans prepared for the erection of a 50 x 50-ft. addition to its power house on 9th St., here.

N. J., Perth Amboy—City plans to extend its street-lighting system for which $25,000 has already been appropriated.

Ohio, Cleveland—The Municipal Electric Light Co. plans to improve its plant including the installation of new equipment involving a switchboard, generator, boilers and engines. About $700,000 will be expended. R. Hoffman, City Engr.

Ohio, Columbus—The Columbus Railway, Power and Light Co. has petitioned the Public Utilities Commisison for permission to issue $1,276,000 in capital stock and bonds; the proceeds will be used in additions and improvements in connection with its new plant. H. W. Clapp, Gen. Supt.

Ohio, Salineville—City voted $25,000 bond issue for the erection of an electric-lighting plant.

Okla., Commerce—The Triangle Mines Co. plans to install an electric-lighting and power plant. N. C. Barry, Pres.

Penn., Hazleton—The Harwood Electric Co. is having plans prepared for the erection of extensions to its plant.

Penn., Philadelphia—Wallace & Co. plans to build a 28 x 95-ft. power house on 81st St. and Island Rd. Estimated cost, $10,000.

Penn., Somerset—The Johnstown & Somerset Ry. plans to install new equipment in its 300-kw. substation. U. S. Houck, Supt.

Tex., Ft. Worth—The Fort Worth Power and Light Co. has increased its capital stock from $3,860,000 to $4,360,000 and plans to install new equipment in its power plant including a new 23,000-hp. steam turbine generator. A. H. Duncan, Mgr.

Va., Lynchburg—The Retail Merchants' Association plans to install an electric-lighting plant.

Va., Petersburg—The Petersburg & Appomattox Electric R.R., Sycamore St., is having plans prepared by F. A. Bishop, Arch., for the erection of a 1-story central heating plant at Lakemont, near here. J. A. Baird, Supt.

Wash., Everett—City is having plans prepared by Burn & McDonnell, Engrs., 400 Inter-State Bldg., Kansas City, Mo., for the erection of a power plant. Estimated cost, $800,000. Noted Oct. 2.

Wash., Kalama—The Kalama Lumber and Shingle Co. plans to improve its plant, including the installation of a new boiler plant and other machinery.

Wash., Puget Sound—(Bremerton P. O.)—(Official)—Bureau of Supplies and Accounts, Navy Dept., Wash., will soon receive bids for furnishing at Navy Yard, Puget Sound, under Schedule No. 1638; 1000 ft. rubber-insulated interior communcation cable; 1000 ft. lighting and power wire; 10,000 ft. single-conductor lighting and power wire; 5000 ft. two-conductor lighting and power wire.

Wash., Seattle—Skinner & Eddy, 150 Massachusetts St., has been granted a permit to erect a power plant. Estimated cost, $3000.

Wash., Shelton—The Shelton Light and Power Co. has petitioned the County Commissioners for a franchise to build and operate a transmission line from its plant at Goldsborough Creek over the county roads.

W. Va., Fairmont—The Greater Fairmont Investment Co. is considering plans for the erection of a 10,000-kw. generating station.

Wis., De Pere—The Western Manufacturing Co. of De Pere plans to build a boiler house. Estimated cost, $45,000.

Wis., Gresham—City plans to install an electric-lighting plant and water-works system.

Wis., Janesville—The Janesville Electric Co. plans to build an addition to its power house.

Wis., Madison—City is having plans prepared for the erection of a substation on Sprague St., in the Wingra Sewer District. E. E. Parker, City Engr.

Prices—Materials and Supplies

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

ELECTRICAL SUPPLIES

KNIFE SWITCHES—Following are net prices each in cities named for knife switches mounted on slate base, front connected, punched clip type, 250 volts:

	30 Amp.	60 Amp.	100 Amp.	200 Amp.
D. P. S. T. fuseless	$0.52	$0.93	$1.90	$3.42
D. P. S. T. fused	.81	1.37	2.70	5.14
D. P. D. T. fuseless	.88	1.52	3.42	5.70
D. P. D. T. fused	1.67	2.58	5.62	9.88
T. P. S. T. fuseless	.78	1.40	2.86	5.14
T. P. S. T. fused	1.32	2.05	4.18	7.70
T. P. D. T. fuseless	1.37	2.35	5.24	8.82
T. P. D. T. fused	2.68	4.13	8.99	15.80

Lots $25 and more, list.

FUSES—Following are net prices of 250-volt inclosed fuses each, in standard packages, in cities named:

0-30 amperes	$0.11¼ each	110-200 amperes	$0.90 each
31-60 amperes	.15¾ each	225-400 amperes	1.62 each
61-100 amperes	.40 each		

FUSE PLUGS (MICA CAP) PER 100

0-30 amperes.. 4c. each in standard package quantities (500)
0.30 amperes.. 5c. each for less than standard package quantities (500)

SOCKETS, B. B. FINISH—Following are net prices in cents each in standard packages:

⅛-IN. OR PENDANT CAP			⅜-IN. CAP		
Key	Keyless	Pull	Key	Keyless	Pull
22.10c.	21.00c.	42.00c.	27.30c.	26.20c.	46.20c.

Note—Less than standard package quantities, 15% off list.

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.18	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	....
T .P. S. B.	.81	1.80	....
D. P. D. B.	.78	2.10	....
T. P. D. B.	1.35	3.60	....
T. P. to D. P. D. B.	.90	2.52	....

ATTACHMENT PLUGS—Price each, in standard packages:

		Standard Package
Hubbell porcelain	$0.21	250
Hubbell composition	.12	50
Benjamin swivel	.12	....
Current taps	.35	50

CHRISTMAS TREE LIGHT OUTFITS—For 110-volt lighting circuits the price is as follows:

	Per Set
8-light outfit with colored lamps complete	$2.00
16-light outfit with colored lamps complete	4.00
24-light outfit with colored lamps complete	6.00
32-light outfit with colored lamps complete	8.00
For 3½-volt battery circuits:	
8-light outfit with colored lamps complete	1.50

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$21.50
No. 16 cotton twisted	29.00
No. 18 cotton parallel	24.00
No. 16 cotton parallel	36.00
No. 18 cotton reinforced heavy	28.50
No. 16 cotton reinforced heavy	39.40
No. 18 cotton reinforced light	24.00
No. 16 cotton reinforced light	32.00
No 18 cotton Canvasite cord	21.75
No. 16 cotton Canvasite cord	32.00

LOOM—Price per 100 ft., in coils:

	Ft. in Coil			Ft. in Coil	
¼	250	$2.25	¾	150	$7.00
⅜	250	3.50	1	100	10.00
½	200	4.50	1¼	100	12.00
⅝	200	5.75	1½	100	15.00

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York:

No.	Solid, Single Braid	Solid, Double Braid	Stranded, Double Braid	Duplex
14	$10.50	$12.50	$16.00	$24.00
12	15.50	17.88	21.00	35.16
10	21.75	24.50	27.50	48.50
8	30.50	33.75	38.25	67.00
6	....	....	58.76	....
5	....	....	69.20	....
4	....	....	83.10	....
3	....	....	100.00	....
2	....	....	121.25	....
1	....	....	148.75	....
0	....	....	181.60	....
00	....	....	223.75	....
000	....	....	286.00	....
0000	....	....	349.50	....

COPPER WIRE—Prices per 1000 ft. for rubber-covered wire in following cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$11.40	$14.75	$28.90	$13.50	$16.00	$26.00	$11.50	$17.90	$36.40
10	23.30	26.50	52.55	26.00	29.00	....	30.80	34.30	67.60
8	33.10	36.70	73.20	35.00	40.50	....	42.85	46.85	....
6	....	56.20	....	....	65.35	....	69.60	74.10	....
4	....	80.55	....	....	93.65	....	101.75	106.05	....
2	....	120.30	....	....	140.50	....	156.50	163.00	....
1	....	156.75	....	....	182.50	....	201.00	209.50	....
0	....	187.05	....	....	241.00	....	276.00	285.00	....
00	....	252.65	....	....	294.50	....	317.00	330.00	....
000	....	309.35	....	....	361.50	....	417.00	428.50	....
0000	....	376.75	....	....	439.50	....	508.00	516.00	....

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per unit for elbows and couplings:

	Conduit		Elbows		Couplings	
In.	Enameled	Galvanized	Enameled	Galvanized	Enameled	Galvanized
½	$69.70	$74.80	$0.1672	$0.1786	$0.0616	$0.0658
¾	92.00	98.90	.22	.235	.088	.094
1	136.00	146.20	.3256	.3478	.1144	.1222
1¼	184.00	197.80	.4185	.4496	.1581	.1698
1½	220.00	236.50	.558	.5994	.1953	.2098
2	296.00	318.20	1.023	1.10	.2604	.2797
2½	468.00	503.10	1.674	1.80	.372	.3996
3	612.00	657.90	4.464	4.79	.558	.5994
3½	763.60	818.80	9.86	10.59	.744	.7992
4	926.50	991.90	11.39	12.23	.93	.999

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

LOCKNUTS AND BUSHINGS—Following are net prices in standard packages, which are: ½-in., 1000; ¾- to 1¼-in., 100; 1½- to 2-in., 50:

	Locknuts Per 100	Bushings Per 100	Flexible Conduit Box Connections Per 100
½	$1.02	$1.68	$5.62
¾	1.75	4.00	7.12
1	3.00	6.15	10.50
1¼	5.00	8.20	15.00
1½	7.50	10.25	22.50
2	10.00	16.40	30.00
2½	12.30	24.60	67.50

ARMORED CABLES AND BOX CONNECTORS—Following are net prices per 1000 ft. cable and standard package of 100 box connectors in single and double strip:

Wire Gage	Twin Conductor Cable	Twin Conductor Connectors	Three Conductor Cable	Three Conductor Connectors
14	$70.00	$4.59	$103.50	$4.50
12	101.25	4.50	127.50	4.50
10	138.75	4.75	176.25	4.75
8	176.20	5.75	247.50	6.00
6	277.50	6.25	362.40	7.50
4	431.25	7.50	....	....

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B—			No. in	Mazda C—			No. in
Watts	Plain	Frosted	Package	Watts	Clear	Frosted	Package
10	$0.27	$0.30	100	75	$0.65	$0.70	....
15	.27	.30	100	100	1.00	1.05	24
25	.27	.30	100	300	3.00	3.10	24
40	.27	.30	100	500	4.50	4.65	12
50	.27	.30	100	750	6.00	6.25	8
60	.36	.40	100	1000	7.00	7.25	8

Standard package quantities are 10% from above prices. Yearly contracts ranging from $150 up allow a discount of 17% from list.

WIRING SUPPLIES—New York prices for tape and solder are as follows:

Friction tape, ½-lb. rolls	35c. per lb.
Rubber tape, ½-lb. rolls	45c. per lb.
Wire solder, 50-lb. pools	45c. per lb.
Soldering paste, 1-lb. cans	50c. per lb.

MISCELLANEOUS

HOSE—

Fire

	50-Ft. Lengths
Underwriters' 2½-in.	70c. per ft.
Common, 2½-in.	40–10%

Air

	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.55	$0.30	$0.25

Steam—Discounts from list

First grade... 30% Second grade... 30-5% Third grade... 40-10%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition ..... 50–10% Best grade 25%
Standard 40%

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40%	35%
St. Louis	45%	40%
Chicago	30+10%	40+5%
Birmingham	35%	35%
Denver	40%	35%

RAWHIDE LACING—40%.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.77
Asbestos for high-pressure steam	1.54
Duck and rubber for piston packing	.88
Flax, regular	.66
Flax, waterproofed	.99
Compressed asbestos sheet	.99
Wire insertion asbestos sheet	1.21
Rubber sheet	.55
Rubber sheet, wire insertion	.88
Rubber sheet, duck insertion	.44
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided, and graphited, for valve stems and stuffing boxes	1.10
Asbestos wick, ½- and 1-lb. balls	.65 to .70

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard Thickness Per L.in.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure ..... 15% off

For low-pressure heating and return lines { 4-ply ..... 58% off; 3-ply ..... 60% off; 2-ply ..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Chicago	St. Louis	Birmingham	Denver
Cup	5½	5.6	8½	10½
Fiber or sponge	6	5.9	15	15
Transmission	6	5.9	10	15
Axle	4	3.3	3	5
Gear	4½	6	5½	5½
Car journal	3½	3.75	5	5

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Dec. 28, 1917	One Year Ago	Cleveland	Chicago
White	11.00 to 13.00	10.00 to 12.00	16.00	14.00 to 15.00
Colored mixed.	8.50 to 12.00	7.00 to 9.00	14.00	10.00 to 12.00

WIPING CLOTHS—In Cleveland the jobbers' price per 1000 is as follows:

13¼ x 13¼ ..... $35.00 13¼ x 20½ $45.00

In Chicago they sell at $30@33 per 1000.

LINSEED OIL—These prices are per gallon:

	New York		Cleveland		Chicago	
	Dec. 28, 1917	1 Year Ago	Dec. 28, 1917	1 Year Ago	Dec. 28, 1917	1 Year Ago
Raw in barrels	$1.28	$0.96	$1.25	$1.00	$1.25	$1.03
5-gal. cans	1.38	1.00	1.49	1.10	1.35	1.13

WHITE AND RED LEAD in 500-lb. lots sell as follows in cents per pound:

	Red				White			
	Dec. 28, 1917		1 Year Ago		Dec. 28, 1917		1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil		
25- and 50-lb. kegs	11.50	11.00	10.50	11.00	10.50	10.50		
12½-lb. keg	11.75	11.25	10.75	11.25	10.75	10.75		
100-lb. keg	11.25	11.50	11.00	11.50	11.00	11.00		
1- to 5-lb. cans	13@25	13.00	12.50	12.50	13.00	12.50		

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	30%	30%	40%*
Tinned	30%	30%	40%*

*For less than keg lots the discount is 35%.

Button heads, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York ..... $7.00 Cleveland ..... $6.85 Chicago $5.50

Coneheads, same sizes:

New York ..... $7.10 Cleveland ..... $6.95 Chicago $5.60

AMMONIA—Below are prices per lb. in cities named:

	New York	Chicago	St. Louis
26-deg. U.S.P. carboys of 100 lb.	16c.	12c.	....
26-deg. U.S.P. drums of 1000 lb.	14c.	10c.	12c.

Anhydrous ammonia in 100-lb. cylinders costs 30c. per lb. in St. Louis, Chicago and New York.

FIRE BRICK—Quotations on the different kinds in the cities named are as follows, f.o.b. works:

	New York	Chicago
Silica brick, per 1000	$50.00 to 55.00	$50.00
Fire clay brick, per 1000, No. 1	45.00 to 55.00	.....
Magnesite brick, per net ton	135.00 to 145.00	.....
Chrome brick, per net ton	135.00	.....
Deadburned magnesite brick, per net ton	85.00 to 90.00	.....
Special furnace chrome brick, per net ton	60.00 to 70.00	60.00 to 80.00

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—High grade, $55 to $65; St. Louis grade, $40 to $50.

Birmingham—Fire clay, $25 to $30; Denver, $23, per 1000.

Chicago—Second quality, $25 per ton.

FUEL OIL—Price variable, depending upon stock. New York quotations not available owing to this fact. In Chicago and St. Louis the following prices are quoted:

	Chicago	St. Louis
Domestic light, 22-26 Baumé	5¼c.	4½–4¾c.
Mexican heavy, 12-14 Baumé	7c.	....

Note—There is practically no fuel oil in Chicago at present time.

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Dec. 28, 1917	One Year Ago
New York	$15.00	$7.50
Cleveland	15.30	7.50
Chicago	15.00	5.75

In coils an advance of 50c. usually is charged.

Note—Stock very scarce generally.

POLES—Prices on Western red cedar poles:

	New York	Chicago	St. Louis	Denver
6 in. by 30 ft	$5.59	$4.94	$4.94	$4.32
7 in. by 30 ft	7.40	6.60	6.60	5.80
7 in. by 35 ft	10.70	9.60	9.60	8.55
8 in. by 35 ft	12.20	10.90	10.90	9.65
7 in. by 40 ft	12.35	11.00	11.00	9.75
8 in. by 40 ft	13.75	12.15	12.15	10.65
8 in. by 45 ft	18.20	16.20	16.20	14.30
8 in. by 50 ft	21.85	19.45	19.45	17.15

10c. higher freight rates on account of double loads.

For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft	$6.00
12-in. butts, 6-in. tops, length 30-40 ft	8.50
12-in. butts, 6-in. tops, length 41-50 ft	9.50
14-in. butts, 6-in. tops, length 51-60 ft	17.00
14-in. butts, 6-in. tops, length 61-71 ft	18.50

PIPE—The following discounts are for carload lots f.o.b. Pittsburgh: basing card of Nov. 6, 1917, for steel pipe and for iron pipe:

BUTT WELD

Steel			Iron		
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼ and ⅜	44%	17%	¾ to 1½	33%	17%
½	48%	33½%			
¾ to 3	51%	37½%			

LAP WELD

2	44%	31½%	2	26%	12%
2½ to 6	47%	34½%	2½ to 4	28%	15%
			4½ to 6	28%	15%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	40%	22½%	¾ to 1½	33%	18%
½	45%	36½%			
¾ to 1½	49%	36½%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	42%	30½%	2	27%	14%
2½ to 4	45%	33½%	2½ to 4	29%	17%
4½ to 6	44%	32½%	4½ to 6	28%	16%

Note—National Tube Co. quotes on basing card dated Apr. 1.

From warehouses at the places named the following discounts hold for steel pipe:

Black	New York	Chicago	St. Louis
¾ to 3 in. butt welded	38%	42.8%	40.1%
3½ to 6 in. lap welded	18%	38.8%	36.1%

Galvanized	New York	Chicago	St. Louis
¾ to 3 in. butt welded	22%	27.8%	25.1%
3½ to 6 in. butt welded	List	24.8%	22.1%

Malleable fittings, Class B and C, from New York stock sell at list price. Cast iron, standard sizes, 15 and 5%.

BOILER TUBES—The following are the prices for carload lots f.o.b. Pittsburgh, announced Nov. 13, as agreed upon by manufacturers and the Government:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	34	3½ to 4½ in.	12½
2½ to 3¼ in.	24	3 to 3¼ in.	+ 5
2¼ in.	17½	2½ to 2¾ in.	+ 7½
1¾ to 2 in.	13	2 to 2¼ in.	+22½
		1¾ to 1⅞ in.	+35

Standard Commercial Seamless—Cold drawn or hot rolled:

Per Net Ton		Per Net Ton	
1 in.	$340	1¾ in.	$220
1¼ in.	280	2 to 2½ in.	190
1¾ in.	270	2¾ to 3¾ in.	180
1½ in.	220	4 in.	200
		4½ to 5 in.	220

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.